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SOME LARGE ENGINES IN THE POWER PLANT OF THE ST. LOUIS EXHIBITION.

The power plant of the St. Louis exhibition (aggregating some 35,370 HP. and a generating capacity of 23,150 KW.) was described in our issue of Sept. 15, and that section of the power plant generating current for the intramural electric railway was described in further detail in our issue of Oct. 13. In the present article we deal with the details of some of the other engines mentioned in the first article.

REYNOLDS-CORLISS ENGINE.

The largest and most powerful engine in the whole exposition was a 5,000 HP. Reynolds-Corliss engine, driving a 3,500 KW. Bullock alternating-current generator for 6,600 volts, 25-cycle, three-phase current. It was built by the Allis-Chalmers Co., of Chicago. The high-pressure cylinder is horizontal, 44 × 60 ins., with double ports in valves and cylinder. The low-pressure cylinder, 94 × 60 ins., is vertical, with single-port heads and double-port valves. The engine takes steam at 150 lbs. and runs at 75 revolutions per minute. The receiver is vertical, and its upper part serves as the steam pipe of the low-pressure cylinder; no reheater is used. The length of bedplate is 39 ft., and the engine is 39 ft. high. Fig. 1 is a view of the engine.

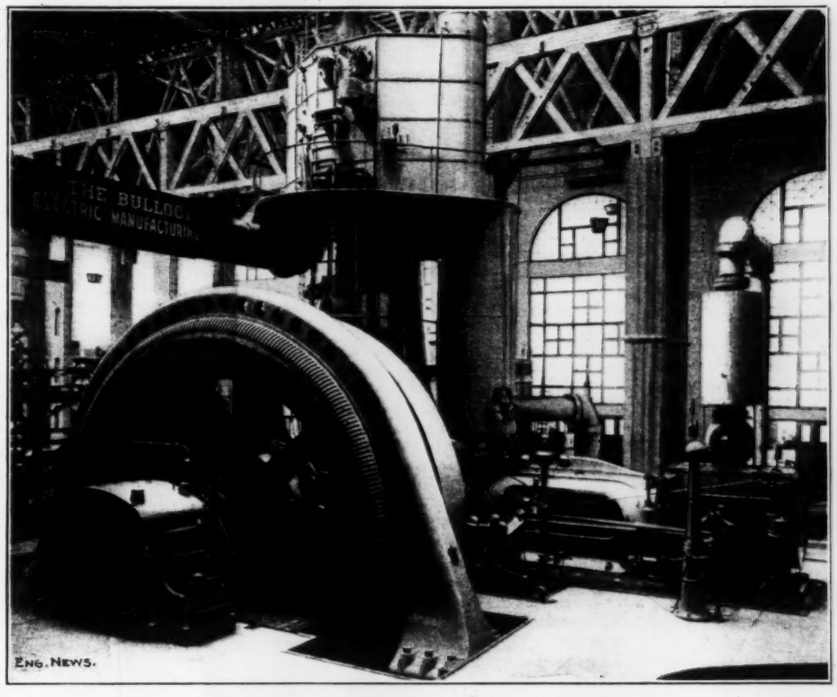


FIG. 1. REYNOLDS-CORLISS ENGINE OF 5,000-HP. AT THE ST. LOUIS EXHIBITION.
Allis-Chalmers Co., Chicago, Builders.

The pistons are built up of body, bull ring and follower: The two latter parts are of cast iron, while the body is of cast steel for the high pressure and so-called "semi-steel" for the low pressure. The pistons have taper fits for the piston rods (9 and 10 ins. diameter) which are held by nuts. The outer ends of the rods are screwed into the crossheads, which are of cast steel, with open-hearth steel pins 14 × 14 ins. The connecting rods are 13 ft. 9 ins. long c. to c., with solid ends at the crossheads and strap ends at the cranks. Both rods are fitted to the same crank pin, with bearings 20 × 9 ins. The pin is of nickel steel, 20 ins. diameter and 18 ins. long, pressed into a cast steel crank of the fantail type, weighing 32,000 lbs. Each connecting rod has a 9-in. bearing on the pin, and the cylinders are therefore set with their center lines offset 9 ins. The shaft is an open-hearth hollow steel forging, 37 ins. diameter at the wheel and generator seats, and 30 ins. at the crank seat, with a main bearing 34 × 60 ins., and outboard bearing 32 × 48 ins. The shaft is 13 ft. 4 ins. long c. to c. of bearings, has a 16-in. hole, and weighs 32,000 lbs. The flywheel is 25 ft. diameter, with a rim 30 ins. wide and 33 ins. deep. It is built up of ten sections, each comprising one arm and a segment of the rim. Its weight is 300,000 lbs., and the total weight of the revolving parts (crank, shaft, flywheel and generator) is 514,400 lbs.

The valve gear is designed for long range cut-off under control of the regulator. Only two eccentrics are employed, one for the steam and the other for the exhaust valve; each eccentric operates two rods, one vertical and the other horizontal. The high-pressure cylinder has only a wrist plate for the exhaust valve, the steam valves being operated directly from the hook rod. The releasing gear is of the Reynolds type. The high-pressure valves are placed in the cylinder casting, both valves and cylinder being double ported. The low-pressure valves are placed in the cylinder heads, and are double ported, while the heads are single ported. The governor controls both cylinders, and has connected to it a safety stop (riding on the governor belt), hand and electric synchronizers, and a hand lever for adjusting the cut-off in the low-pressure cylinder. The valve and port dimensions are as follows:

	HP.	LP.
Steam pipe, diameter.....	14 ins.	30 ins.
Exhaust pipe, diameter.....	16 "	34 "
Valves, diameter	10 "	16 "
Area of steam port.....	150 sq. ins.	712 sq. ins.
Area of exhaust port.....	206 " "	930 " "

This engine and a De Laval steam turbine (the latter not a part of the power plant) have the vacuum maintained by an Alberger barometric condenser equipment, the air and circulating pumps of which are driven by a vertical Corliss engine. A Connersville rotary circulating pump is connected directly to the engine shaft; the vertical pump is mounted upon frames similar to the engine frames and is driven by an extension of the crank shaft. The exciter current for the large generator is furnished by a Bullock 200 KW. generator for 250-volt direct-current, driven by a 300-HP. horizontal Ideal engine.

HAMILTON-CORLISS ENGINE.

A vertical cross-compound Corliss engine of 2,500 HP., with cylinders 34 × 54 and 68 × 54 ins., and running at 83 revolutions per minute, forms the exhibit of the Hooven, Owens, Rentschler Co., of Hamilton, O., and is the first vertical engine built by that firm. The cylinders are set 22 ft. 6 ins. apart, c. to c., and the height from the floor is 27 ft. 9 ins.

The valves are double-ported, have a very short travel, and are located in the cylinder barrels, but are so placed that the clearance is about the same as if they were located in the cylinder heads. To effect this, the exhaust valves are brought partly within the cylinder walls, but clear of the space swept by the piston, which, however, sweeps past the ports. The steam ports are so arranged as to be clear of the piston space, so that the incoming steam strikes the piston squarely on the end. The valves are 7½ and 12¾ ins. diameter in the high and low-pressure cylinders, respectively. The steam and exhaust valves are operated by separate eccentrics with direct rod connections, there being no wrist plates. The cut-off averages 23 per cent. The dash pots are hung from the valve bonnets, and have the moving parts much lighter than usual. Fig. 2 shows the valve gear on the high-pressure cylinder. From this it will be seen that the hook and steam lever are at the outer end of the valve stem, with the knock-off or release lever, and cam on the inner side. For the exhaust valves, the hook rod is attached to one arm on a shaft having a shorter arm which is connected to the lever on the valve stem by a short link.

Each main frame is composed of three castings; the bed-plate, the A-frame, and the guide barrel. The shaft is carried on water-cooled bearings, each of which is lubricated by a stream of oil

from a receiver, to which it is pumped by an oil pump driven from the eccentric. The shaft is 30 ins. diameter at the wheel seat, and has bearings 25 × 42 ins. At each end is a disk crank, driven by a solid-end connecting rod. On the shaft is a 22-ft. flywheel weighing 120,000 lbs. The engine is controlled by a high-speed governor of the center-weight flyball type, with motor and micrometer attachment to regulate the speed from the switchboard for throwing the generator in parallel. The engine is fitted with the Monarch safety-stop, and with a safety-stop held open by an arm having an idler pulley bearing against the governor belt. Should the belt break, the arm will fall and allow the governor to drop into a position which will cut off the steam.

This engine and the same company's steam turbine are connected to a Stilwell-Bierce & Smith-Vaile surface condenser.

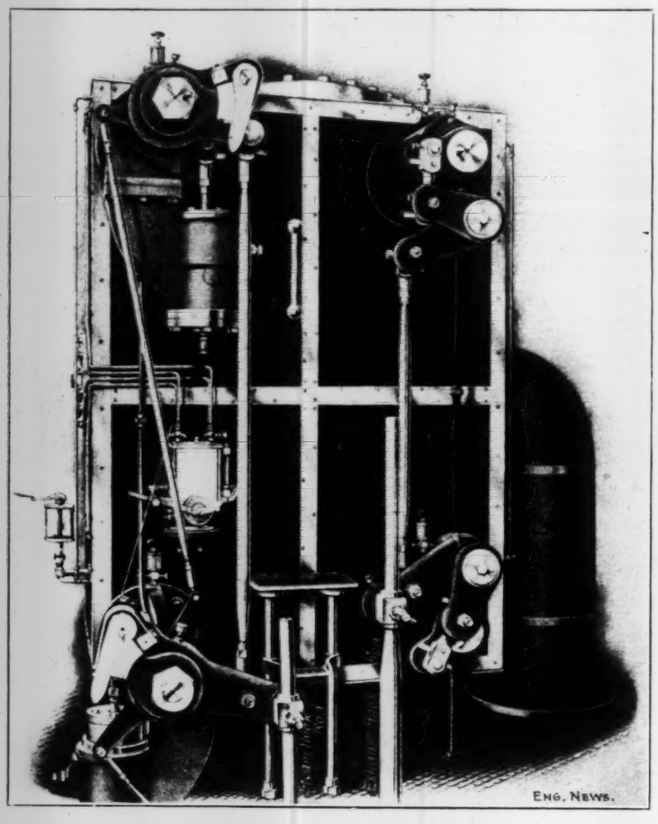


FIG. 2. HIGH-PRESSURE VALVE GEAR OF HAMILTON CORLISS ENGINE OF 2,500 HP.
Hooven, Owens, Rentschler Co., Hamilton, O., Builders.

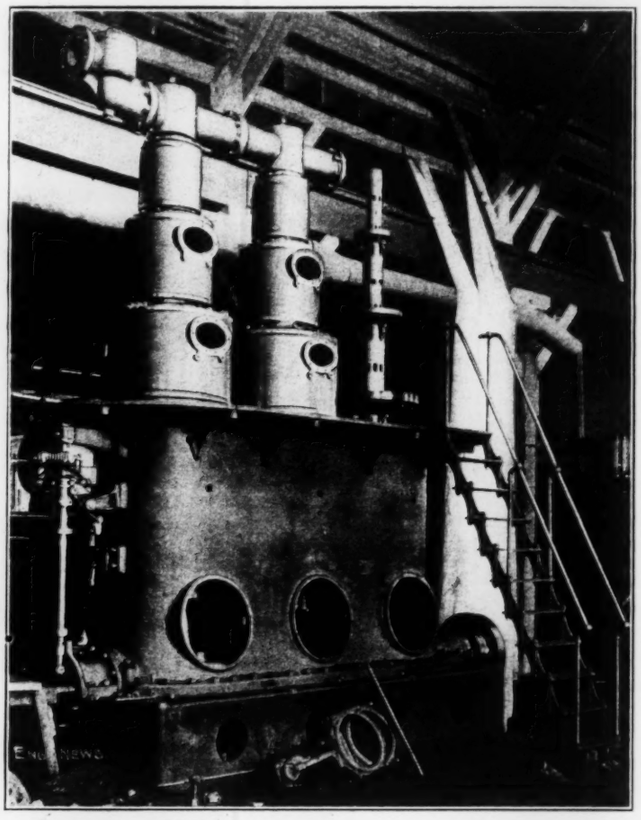


FIG. 3. WILLANS CENTRAL-VALVE ENGINE OF 1,000-HP. BEING ERECTED.
C. H. Bradley, Jr., & Co., Pittsburg, Pa., Builders.

THE WILLANS ENGINE.

The Willans high-speed central-valve single-acting vertical engine has been quite largely used in England, but in this country its use is comparatively limited. Its introduction here was first undertaken by the late M. C. Bullock, of the Bullock Mfg. Co., Chicago; it is now, however, in the hands of C. H. Bradley, Jr., & Co., of Pittsburg, who exhibit two of these interesting engines as follows: 1, A triple expansion, single-acting condensing engine of 1,000 HP., designed for 175 lbs. steam pressure, and running at 277 revolutions per minute; this has three sets of triple expansion cylinders, or nine cylinders in all, and is directly connected to a 600 KW. revolving field, 2,300-volt, two-phase generator exhibited by the Stanley Electric Mfg. Co.; 2, a compound single-acting condensing engine of 50 HP., designed for 150 lbs. steam pressure, and running at 460 revolutions; this has two sets of compound cylinders, or four cylinders in all, and is directly connected to a 30 KW., 125-volt, direct-current generator exhibited by the Northern Electrical Mfg. Co., of Madison, Wis. This generator is used to excite the large generator and also to furnish current for a 25-HP. motor driving an 8-in. Worthington volute circulating pump for the Worthington surface condenser; the air pump is a Blake twin-beam pump.

The cylinders are vertical, mounted tandem, with the pistons attached to a hollow trunk piston rod in which the steam and exhaust ports are formed. This is shown at the right in Fig. 3, which is a view of the 1,000 HP. engine during erection. Within the piston rod works a vertical valve rod fitted with disks which form the valves, and which is driven from an eccentric forged on the crank pin at the main shaft. The only pin in the valve gear is that which connects the eccentric rod with the crosshead of the valve rod. In order to allow of placing the eccentric in line with the valve rod, the bottom piston carries two connecting rods, which are attached directly to the piston. The intermediate and low-pressure receivers are chambers forming the upper parts of the respective cylinder castings, and having direct communication with the cylinder above. Beneath each low-pressure cylinder is an air cushion chamber in which air is compressed on the up-stroke and expanded on the down-stroke. These compensate for inertia in the reciprocating parts, so that there is no reversal of stress and all bearings are kept in constant thrust, thus eliminating pounding and reducing wear. The flywheel is a solid casting, 6 ft. 6¾ ins. diameter, weighing about 31,500 lbs., and keeps the speed variation of the engine within the limit required for the parallel operation of 60-cycle generators. It serves as half of the coupling for the attachment of the armature shaft.

The cut-off in the high-pressure cylinder is 0.6, which can be altered to any less amount or up to 0.7, as may be required. In the intermediate and low-pressure cylinders the cut-off is 0.55 and 0.6. With 175 lbs. steam pressure, developing 1,000 HP., condensing, the steam is expanded about 10.7 times. The point of cut-off is independent of the valves, and is effected by the ports being closed as they pass through the stuffing boxes (with metallic packing) on top of each cylinder. This makes the cut-off very sharp and no compression is required in the steam cylinders, as the air-cushion chamber absorbs all inertia. The indicator cards are said to closely resemble those from Corliss engines, in spite of the high speed of the Willans engine. The governor is of the spring-loaded fly-ball type, operating a throttling governor valve, and can be adjusted while the engine is running to vary the speed about 10%, either faster or slower. The variation in speed from no load to full load is about 5%. The throttle closes by moving downward, and in case the governor should break the valve will be automatically closed by the weight of governor rods and valve stem and the tension of the adjusting spring.

GREENWALD FOUR-VALVE ENGINE.

A peculiar arrangement of valves and valve gear is seen on a 600-HP. cross-compound engine. The valves are operated from cams and eccentrics on a lay shaft parallel with the engine. The engine has cylinders 18 × 42 ins. and 36 × 42 ins., and runs at a speed of 100 revolutions per minute. It was built by the I. & E. Greenwald Co., of Cincinnati, O., and drives a Fort Wayne 400-KW. 250-volt direct-current generator.

The valves and valve gear form the special features of this engine. There are four gridiron slide valves; the two steam valves are at the side of the cylinder and move vertically; the two exhaust valves are beneath the cylinder and move horizontally, at right angles to the axis of the cylinder. They are operated by cams and eccentrics on a shaft parallel with the engine and driven from the main shaft by a train of gearing. On the end of the side shaft is a bevel wheel gearing with another on a shaft, which also carries a spur gear; the latter engages with another, which in turn gears with a third on the main shaft.

In the details of the valve gear shown in Fig. 4, A is the side shaft, and B the steam eccentric, with arm C carrying the lifting lever D, pivoted at E. The end of the lever D engages with the hook F, which is pivoted to the vertical arm G, and G is therefore raised, carrying with it the valve stem H and valve. When the travel is sufficient for the tail of hook F to engage with the trip J (operated by the governor), the hook will be disengaged from lever D and the arm and valve will drop. The arm G is connected to the dash-

pot rod. The exhaust valves are operated directly from the side shaft A, by means of cams, K; a roller riding in the groove of the cam is attached to a pin in the arm L, which (with its upper arm M) is given an oscillating movement. The valve stem is attached to the upper end of arm M, and has a sliding box which provides for the slight rocking motion due to the traverse of the arm.

The governor is of the enclosed fly-ball type, and is operated from the side shaft by bevel gearing N, N, as shown in Fig. 5. The governor rod, O, is attached to the link P, operating the bell crank, Q, the upper arm of which is attached to the cut-off rod operating the arms R of the tripper J. As the governor is speeded up, the trip J is lowered so as to engage the hook F sooner and so

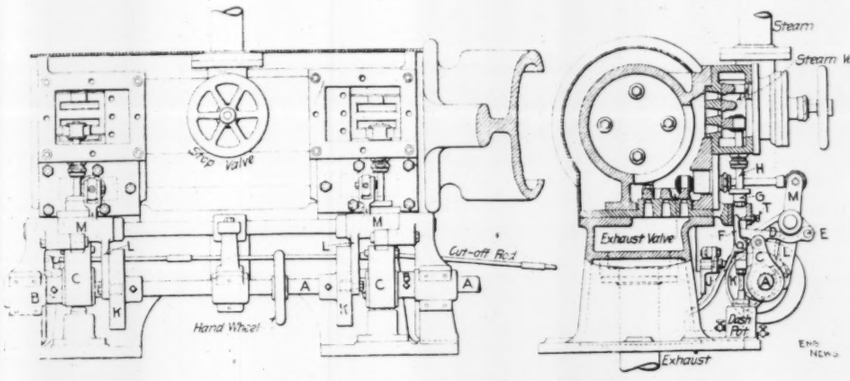


FIG. 4. VALVE GEAR OF GREENWALD FOUR-VALVE ENGINE.
I. & E. Greenwald Co., Cincinnati, O., Builders.

effect an earlier cut-off. A weighted lever, S, is attached to the shaft of the bell crank, Q, and the speed can be varied by shifting the position of the weight. When the governor rod is at its lowest position, the arms S keep the hook F from engaging with the lifting rod D. The screw T acts as a positive cut-off by coming in contact with the hook F and disengaging it from the lifting lever D at the extreme throw of the eccentric, or full port opening of valve. A clutch on the lay shaft A can be disengaged by the handwheel shown in Fig. 5, so as to allow of adjusting the valves or opening them to warm up the cylinder before starting.

FRENCH ENGINES.

There are only two examples of foreign steam engine practice, both being of French design and construction. The Societe Delaunay Belleville, of Saint Denis, France, has a vertical quadruple expansion engine of 1,500 HP., with three pair of tandem cylinders. This is a high-speed engine, running at 335 revolutions, and we shall publish drawings of it in a later issue. The Societe Alsacienne de Constructions Mecaniques, of Paris, has a horizontal tandem compound engine of 1,000 HP., with cylinders 24 × 52 and 44 × 52 ins., and running at 94 revolutions. It has the Frickart system of valve gear, with four piston valves to each cylinder, the valves being transverse to the center line of the cylinder and having a horizontal reciprocating motion. They are operated from eccentrics on a lay shaft parallel with the cylinders. The condenser pumps are worked from the cross head.

THE BEST ECONOMY OF THE PISTON STEAM ENGINE AT THE ADVENT OF THE STEAM TURBINE.*

By J. E. Denton,† M. Am. Soc. M. E.

When James Watt retired from business, at the beginning of the nineteenth century, he had declared his belief, based on theoretical calculations, that the water consumption of a steam engine per horse-power decreased with the increase of the ratio of expansion until the pressure of release should be equal to the exhaust pressure. But, although Watt invented a valve-gear with which to test his theory, he never worked steam expansively to any practical degree in any of the engines built by him, because the demand for them simply as multipliers of the power available from other prime movers of that day was at too great a premium to make it necessary for the firm of Boulton & Watt to improve the economy of their engine by the application of the principle of expansion.

As builders of steam engines multiplied, however, economy became the ruling factor of competition and the principle of expansion was applied in the pumping engines of Cornwall, with increasing economy, up to the greatest ratio of expansion consistent with commercial limits of size of cylinder per horse-power. Hence, when in 1840, one of the leading Cornish pumps was reliably tested for water consumption at ratios of expansion varying from 1.5 to 3.5, with results showing from 24 to 16.5 lbs. of steam per HP.-hour, and it was found that these figures agreed with Watt's theory, belief in the latter was practically universal, and expansion was relied upon to yield similar results, in all important engines of land and sea, up to 1855.

The engineers of this time failed to realize, however, that the Cornish pump, with its single action and equilibrium exhaust, never exposed the working-end of its cylinder to the temperature of the condenser, so that the range of temperature to which the admission-end of the cylinder was exposed was only a fraction of that undergone by the steam, a fact which realized the conditions of action of a compound engine. They also failed to realize that the steam was superheated during admission by excessive wiredrawing from the boiler pressure of 45 lbs. to 18 lbs. absolute, and further, that a live-steam jacket heated the cylinder walls to initial temperature during a very slow indoor stroke, while admission occurred during the very quick outdoor stroke.

These facts made it possible for the Cornish pump to act without cylinder condensation—a phenomenon which Watt's theory did not recognize to exist; so that it was consistent that his theory should completely account for the performance of this engine as determined by experiment. But the ordinary double-acting non-jacketed engines of the marine and stationary practice of that day did not realize these passive cylinder-wall actions of the Cornish pump. Consequently it became gradually evident towards 1860 that the steam engines of the world were failing to realize the results due to Watt's theory. This conclusion was deduced from service records of coal consumption tests, as from 1840 to 1860 no impressive water consumption tests were made.

At the latter date, however, Isherwoods' elaborate and thorough tests on the United States steamer "Michigan"

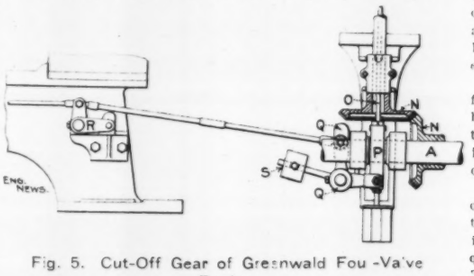


Fig. 5. Cut-Off Gear of Greenwald Four-Valve Engine.

appeared, showing a limit to the gain in steam economy by increasing ratios of expansion through the existence of some action of the steam unknown in its character but evidently not taken account of by Watt's simple theory of expansion.

Rankine's sagacious analysis of the "Michigan" data located this missing factor of the theory in the powerful waste action of the cylinder walls, constituting, with all of its complicated dependence on range of temperature, cylinder surface, speed, and jacket influence, what we now term the "loss due to cylinder condensation." It was then quickly recognized that to realize the gain due to Watt's theory of expansion, the percentage of loss due to cylinder condensation must be confined within certain limits as the ratio of expansion increased, and that it could be by controlling its main factor, (the range of temperature in the cylinder during expansion), through the division of this expansion among successive cylinders.

DEVELOPMENT OF MARINE ECONOMY.

The idea of the subdivision of the range of temperature was first extensively applied in marine practice to compound the simple condensing engine using steam at 60 to 80 lbs. boiler pressure with six expansions without either increasing the boiler pressure or expansion ratio. No practical gain in economy resulted from this change, as, while the range of temperature of the cylinder was cut in two and the cylinder condensation loss thereby reduced, the gain accruing therefrom was neutralized by the mutilation of card area, due to the discontinuity of the expansion curve and the loss of pressure between cylinders. The water consumption, therefore, remained at about 19.5 lbs. per horse-power, which had been afforded by the simple engine.

But the marine boiler-making art had now advanced so as to make 150 lbs. steam pressure available. Therefore, the engine was able to use 14 expansions and secure such an increase in mean effective pressure as would enable a three-cylinder engine to weigh practically no more per horse-power than did that of the compound system. The marine world, therefore, sought the increased economy due to Watt's theory from 14 expansions divided among three cylinders, so that the range of temperature in each cylinder was the same as that in the compound system with lower boiler pressure. The cylinder-condensation loss was thereby controlled so that the gain in economy due to the greater ratio of expansion under Watt's law preponderated over the loss due to broken card area. The result was, taking the merchant marine engines as the standard of economy, that the water consumption fell to 15 lbs. per horse-power. The triple-expansion engine at sea, therefore, afforded the first real gain in economy over the simple engine of six expansions which was prevalent when the phenomenon of cylinder condensation was discovered.

Further development of marine boiler construction now supplies the merchant marine with 210 lbs. of pressure from Scotch fire-tube boilers. This permits the use of 15 expansions with 39 lbs. of total mean effective pressure, or about 30% increase over that of the 150 lbs. triple-expansion engine; this, together with increased revolutions, by virtue of improvements in lubrication and construction of bearings supplemented by more perfect balancing of moving parts and no greater mutilation of card area than in the triple engine, permits the use of four-stage expansion engines whose weight is within satisfactory commercial limits.

With the expansion divided into four stages, in four or more cylinders, the temperature range per cylinder is reduced over that of the triple engine with a resulting reduction of cylinder-condensation loss so as to afford a water consumption of 13.6 lbs. per horse-power-hour of the main engine, with a vacuum of 25.5 ins. This economy is attained without saturated steam without jackets or reheaters, the latter never having shown sufficient gain on marine engines to compensate for the care necessary to manage them; and it applies to all engines above 5,000 HP., the gain in economy due to larger size being indistinguishable by service records.

With an attached air pump, the usual auxiliaries consume steam which increases the water consumption to 14.4 lbs. per horse-power of the main engine. The exhaust of these auxiliaries applied to heating the feed water, supplies it to the boilers at fully 200° Fahrenheit. From this temperature Scotch boilers with Howden's system of draft, burning about 21 lbs. of the best semi-bituminous coal per square foot of grate per hour, evaporate 11 lbs. of actual feed water per lb. of coal. Thus for each indicated horse-power of the main engine 1.3 lbs. of coal are consumed per hour.

Without an increase in boiler pressure above 210 lbs., further increase in economy can only be obtained with higher ratios of expansion and this is prohibited because the consequent reduction of mean effective pressure would increase the weight of the engine per horse-power beyond commercially-acceptable limits.

With higher boiler pressure greater economy can be obtained from the engine by increasing the expansion up to probably a ratio of 30, but to accomplish this without increase of weight of engine per horse-power would require a working pressure of steam of 300 lbs. per sq. in. This must be obtained from water-tube boilers, as the Scotch boiler is now at the limit of practicable construction and allowable weight when built for 210 lbs. steam pressure.

Higher economy of engine is obtainable, with present pressures and ratios of expansion, by the use of superheated steam, but the application of the latter has not thus far shown a gain in coal economy in trans-Atlantic marine practice. This is doubtless ascribable to the use of imperfectly-designed superheaters; but the increase of cylinder oil which superheating requires makes its successful introduction at sea questionable, on account of the difficulty of protecting the boilers against over-fouling by accumulation of oily deposit.

At the advent of the steam turbine in marine practice, therefore, the degree of economy with which it must com-

*A paper presented before the Mechanical section of the International Congress of Arts and Sciences at St. Louis, Sept. 23, 1904.

†Professor of Engineering Practice, Stevens Institute of Technology, Hoboken, N. J.

pete, in marine engines on the largest scale, is that of a quadruple-expansion system expanding saturated steam with 210 lbs. pressure, fifteen times, into a vacuum of 25.5 ins. with an economy of 13.6 lbs. of water per horse-power-hour of the main engine; which will operate, with its auxiliaries, from Scotch boilers on the Howden system, with a consumption of 1.3 lbs. of the best semi-bitumious coal per indicated horse-power-hour of the main engine.

If the turbine could operate screw propellers efficiently with the same rotational speeds for a given horse-power that it uses in electric service, the record for economy already established by the turbine shows its ability to easily compete with these conditions of performance of the best marine engine. But such rotational speeds for the turbine are inconsistent with the degree of screw propeller efficiency available from piston engines.

Therefore the possibilities as regards steam economy of the turbine in marine practice are as yet too unsettled to permit of their definite statement within the limits of this paper.

DEVELOPMENT OF STATIONARY ENGINE ECONOMY.

Stationary engines at the date of the discovery of cylinder condensation were affording the maximum economy in simple condensing cylinders expanding steam of from 60 to 80 lbs. pressure six times, with a vacuum of about 27 ins., which afforded a water consumption of about 19 lbs. per horse-power-hour.

The first noteworthy improvement upon this degree of economy, was obtained in the Leavitt pump at Lawrence, Mass., which by expanding 120 lbs. steam sixteen times in two cylinders secured a water consumption of 16.5 lbs. per horse-power. This, however, was a compound engine without a receiver, or what is known as the "Wolff" system, which does not divide the range of temperature due to expansion between the two cylinders, as the high cylinder is in connection with the low during the whole of the latter's expansion period. This fact and the slow speed of 12 revolutions per minute made the initial cylinder condensation 40%, or, nearly twice that of the six-expansion simple condensing engines; besides which, live-steam jackets on both cylinders consumed 10% of the total steam.

The gain in economy over the simple engine was, therefore, due entirely to the influence of the high ratio of expansion aided by high initial pressure and so strong a re-evaporative effect that the expansion line was outside of a Mariotte curve to the end of the expansion. The combined effect of these more than offset the negative influence of the high percentage of cylinder condensation. The engine was, however, the most economical of its time (1872) and it is interesting to note that its conditions of steam action were widely in contrast with that of the most economical Cornish pumping engine of 1840, which afforded precisely the same water consumption of 16.5 lbs., by expanding 30 lbs. steam 3½ times, with a complete avoidance of loss by cylinder condensation.

The first prominent advance in economy by division of the range of temperature was obtained about 1878 in the Corliss Pawtucket compound pumping engine. This also expanded 120 lbs. steam sixteen times in two cylinders but with a receiver between them; whereby, with the aid of a speed of fifty revolutions and only 5% jacket consumption, the cylinder-condensation loss was reduced to 25%, and a water consumption of only 13.7 lbs. resulted. This result led Corliss to introduce similar compound engines into mill practice and they were then rapidly substituted throughout the world in all large power-using industries, for the single six-expansion condensing engine. All makers of four-valve drop cut-off engines in both the United States and Europe obtained from them a water consumption of from 13.5 to 14 lbs. per horse-power with about 125 lbs. steam pressure and about sixteen expansions.

The gain from one division of temperature being thus established, triple-expansion engines were quickly introduced for mill and electric service by Corliss and Allis in the United States and Sulzer in Germany to obtain a further gain from two divisions of temperature. None of the triple-expansion engines succeeded, however, in reducing the water consumption below 12.5 lbs. per horse-power, which was not a sufficient gain over the compound engine to offset the extra cost and care of the third-expansion stage. Its use was therefore quickly abandoned in mill and electric light service in favor of the compound engine.

Such a general re-adoption of the compound type resulted in a variety of cylinder ratios being used as involving possibilities of improved economy over the ratio of 4 to 1 introduced by Corliss. The first radical departure appeared in the Rockwood & Greene system which was introduced into New England with a cylinder ratio of about 7 to 1, and clearances of about 2%, instead of the 4% value previously prevailing. With 150 lbs. steam pressure, live-steam jackets on either the heads or barrels of both cylinders, and a live-steam reheating receiver, such engines have afforded 12.45 lbs. per horse-power with saturated steam expanded 26 times into about 27.5 ins. of vacuum. Without the jackets and reheater in use, about 2% greater water consumption is obtained. The jackets and reheater, when in use, consume only about 8% of the total steam, with practically 25% of cylinder condensation under both conditions.

This performance represents the best economy derived from the compound engine for mill and electric practice up to within a few years ago, and it has largely established the belief that a cylinder ratio of about 7 to 1, with so small a clearance as 2%, is necessary to maximum compound engine economy. During the last two years, however, the following records have been established:

(1) With an 850 HP. Rice & Sargent compound Corliss engine running at 120 revolutions per minute, having a 4 to 1 cylinder ratio, clearances of 4% and 7%, live jackets on cylinder heads and live steam in reheater, Professor Jacobus of Hoboken found for 600 HP. of load, with 150 lbs. pressure of saturated steam, 28.6 ins. of vacuum and 33 expansions, 12.1 lbs. of water consumption per horse-power—a result produced with a cylinder condensation loss of 22%, and a jacket consumption of 10.7% of the total steam consumption.

(2) With a 250 HP. Belgian Van den Kerchove poppet-valve compound engine, running at 126 revolutions per minute, with 2.97 to 1 cylinder ratio, clearances of 4%, steam chest jackets on barrels and head, and no reheater, Professor Schröter, of Munich, found 117 HP. of load, 130 lbs. pressure of saturated steam, 27.6 ins. of vacuum, and 32 expansions, 11.98 lbs. of water per horse-power—a result produced with a cylinder-condensation loss of 23.5%, and a jacket consumption of 7% of the total steam consumption in the high-cylinder jacket and 7% in the low jacket.

(3) With the Westinghouse twin low-cylinder, compound combined poppet-valve and Corliss-valve engine, at the New York Edison plant, running 76 revolutions, with 5.8 to 1 cylinder ratio, clearances of 10.5% and 4%, without jackets or reheater, Messrs. Andrew, Witham and Wells, found for the full load of 5,400 HP., 185 lbs. steam pressure, 27.3 ins. of vacuum and 29 expansions, 11.93 lbs. of water per indicated horse-power, a result produced with an initial condensation of about 32%.

These facts show that the minimum water consumption of the compound mill engine, and electric light engine of the present date, using saturated steam, is not dependent upon any particular cylinder ratio and clearance nor upon any system of jacketing, but that the essential condition is the use of a ratio of expansion of about 30, above which the cylinder-condensation loss is liable to prevail over the influence of the law of expansion. The conclusion appears warranted, therefore, that if this ratio of expansion is secured with any of the current cylinder and clearance ratios, and with any existing system of jackets and reheaters, or without them, a water consumption of 12.4 lbs. per HP. is possible, and that a variation of four-tenths of a pound below or above this figure may occur by the accidental favorable, or unfavorable, jacket and cylinder-wall expenses which are beyond the exact control of the designer.

COMPOUND PISTON ENGINE ECONOMY VS. THAT OF STEAM TURBINE.

In order to compare the economy of the piston engine with that of the steam turbine, we must use the water consumption per brake horse-power, since no indicator card is possible from the turbine; and furthermore, we must use the average water consumption for the range of loads to which engines are subject in practice.

In all of the public turbine tests to date, with one exception, the output was measured through the electric power of a dynamo whose efficiency is not given for the range of loading employed, so that the average brake horse-power is not known. This exception is the Dean and Main test of a 600 HP. Westinghouse-Parsons turbine using saturated steam at 150 lbs. pressure, and a 28-in. vacuum. We may compare the results of this test with that of the 850 HP. Rice & Sargent engine, and the 250 HP. Belgian engine, by assuming that the power absorbed by friction in these engines is 3% of the indicated load plus the power shown by friction cards taken with the engine unloaded. The latter showed 5% of the rated power in the case of the Rice engine and 8% in the Belgian engine; so that the assumption regarding the load friction is a reasonable one.

The results are given in the following table, which shows the average water consumption per horse-power, for from 40% to 125% of full load, to be 14.55 lbs. and 14.64 lbs. for the two piston engines, and 14.51 lbs. for the turbine, or practical equality.

Average Steam Consumption per Brake Horse-Power of Piston Engine versus Turbine.

	Lbs. water per brake HP. hour.		
Per cent. of full load	600-HP. turbine.	850-HP. Rice engine.	250-HP. Belgian engine.
125	13.62	13.78	15.10
100	13.91	13.44	14.15
75	14.48	13.66	13.99
41	16.05	17.36	15.31
Average 85	14.51	14.56	14.64

As an indication of the gain in economy of the turbine with increase of size, we may use the Elberfeld test of a Parsons turbine at the full load of 1,500 electric HP., with an allowance of 5% for attached air pump, and an assumed minimum generator efficiency of 0.95. Its saturated steam consumption, with 150 lbs. boiler pressure and 28 ins. of vacuum, is then 13.08 lbs. per brake HP. hour, which shows a gain of 4% over the 600-HP. machine.

The 5,400-HP. Westinghouse compound engine at the New York Edison station, whose friction under full load was cleverly determined at about 4%, affords a brake HP. consumption of 12.5 lbs. for 185 lbs. boiler pressure. Crediting the turbine, therefore, with the possible influence of the difference in size and steam pressure, there is again practical equality in economy between it and the piston engine for equal horse-power.

DEVELOPMENT OF PUMPING ENGINE ECONOMY.

While the mill and electric practice has developed the compound engine, pumping engines in the United States have been developed in the triple-expansion fly-wheel type to a degree of economy superior to that afforded by any compound mill or electric engine, and, for saturated steam, superior to that of the pumping engines of any other country. This is because their slow speed permits of greater benefit from jackets and reheaters and of less losses from wiredrawing and back pressure. These causes, together with the greater subdivision of the range of cylinder, have resulted in records made between 1894 and 1900 of 11.22, 11.26 and 11.05 lbs. of saturated steam per indicated horse-power, with 175 lbs. steam pressure and from 25 to 33 expansions, in the cases of the Leavitt, Snow and Allis pumping engines, respectively, the corresponding heat consumptions being by different dispositions of the jacket drainage, 204, 208 and 212 thermal units per indicated horse-power-minute; while later the Allis pump, with 85 lbs. steam pressure, has lowered the record to 10.33 lbs. of saturated steam per indicated horse-power, with 196 heat units of consumption per horse-power-minute.

The turbine can compete with these pumping engines only through the medium of a multiple-stage centrifugal pump, whose efficiency taken even at 80% will probably impose too great a loss of motive power on the turbine system for successful competition with this high class of piston pump, since the friction loss of the latter is only 5% of the indicated horse-power.

GAIN FROM SUPERHEATING AND FROM THE SULPHUR DIOXIDE EXHAUST HEAT ENGINE.

For opening the way to the improvement of the economy of the piston steam engine beyond any degree represented by the results we have thus far presented, we must make our bow exclusively to the Germans. By their revival of the use of superheated steam, after it had been twice abandoned in the history of steam engineering, they have demonstrated the practical success of superheating to raise the economy of any engine, whatever its boiler pressure or ratio of expansion, by rendering the steam a more efficient working medium on its entry to the engine. By showing that after the steam has been expanded to its greatest practical limits in piston engines an important amount of power can still be practically abstracted from it in the sulphur dioxide engine they have also reduced the waste accompanying its exit from the engine.

Previous attempts to use superheated steam failed because of the lowered efficiency of the boiler through the location of the superheating device in the chimney. Here the superheater was so arranged that the exit temperature of the heated gases had to be in excess of the superheated steam temperature to such a degree that the boiler's economy was lowered; and also the superheating surface so located and in contact only with steam was rapidly corroded. These defects the Germans have overcome by arranging the superheater so that it receives wet steam at the chimney end of the system, and lies at the middle of the flame current at the point where the superheated steam is delivered from it to the engine. Thus the hot gases can enter the chimney at no higher temperature than is consistent with the best economy from saturated steam boilers, and experience thus far shows no impracticable rate of depreciation of the superheater from corrosion.

The difficulty of conveying highly superheated steam from the boiler to the engine without excessive loss of temperature has also been overcome by improved and thicker pipe installation and the use of about half the pipe section usually employed for saturated steam. The generator plant has therefore been perfected so that it does not handicap the value of the superheated steam to the engine, while the latter is adopted to work the steam without lubrication difficulties by the use of poppet valves on at least the initial cylinder.

The maximum of improvement in economy over saturated steam may be briefly summarized in the following extract from an admirable investigation by the most distinguished European authority on engine tests, Professor Schröter, of Munich: The engine used was the compound 250 HP. 13 and 21 × 33-in. Belgian Van den Kerchove construction, previously mentioned, operating with a boiler pressure of 130 lbs., and 27.6 ins. of vacuum, with 30.18 ins of barometer. For saturated steam the average water consumption for five divisions of load, between 40 and 125% of rated load is 12.45 lbs. per English indicated horse-power-hour, with 3.6% of steam condensed in the high jacket at 130 lbs. pressure, and 9% in the low jacket, including the receiver, at 5 lbs. pressure. Assuming the jacket drainages applied to heat the feed water from a temperature of 108° in the hot well, 136° F. feed

temperature would be afforded. Reckoning the expense of heat from this temperature, the consumption is 223 thermal units per indicated horse-power-minute.

With steam superheated 224° F. above saturation, or at 304° Centigrade, the average consumption for the same divisions of load is 10.09 lbs. of feed water per horse-power. With one-third of 1% high jacket and 3% low jacket and receiver consumption, the jacket water would heat the feed water to 115° F. at the same hot-well temperature. Reckoning from this temperature, with a specific heat value of 0.6, according to the experiments of Lorenz and of Bach, the heat expense is 209 thermal units per horse-power-minute. The average gain by superheating 224° Fahrenheit is therefore 7%. If the feed water were heated to 200° by auxiliaries, the heat unit gain would be 8%.

With steam superheated 307° F. above saturation, or at 350° C., and the load at about 80% of rating, the water consumption was 8.99 lbs. per English HP., with 0.4 of 1% condensation in the high jacket and 4% in the low. This affords 114° F. temperature, and with a specific heat of say 0.57 (since according to Lorenz's experiments the specific heat reduces with increase of superheat at any given pressure), we have a heat consumption of 192 thermal units per horse-power-minute. The same load with saturated steam affords 137° F. of feed temperature and gives 221 units of heat consumption per horse-power. The gain for 307° superheating over saturated steam for the same horse-power is, therefore, 13% from the natural feed temperature and for 200° feed, 14%.

The best performance reported for superheated steam used in the turbine is that of Brown & Boveri Parsons Frankfort 4,000-HP. machine, which, with 183 lbs. boiler pressure above the atmosphere and 190° F. superheat, afforded 10.28 lbs. per brake horse-power, assuming a generator efficiency of 0.95. Reckoning from the feed temperature of its vacuum of 27.5 ins., and using a specific heat value of 0.65, the heat consumption is 214 thermal units per horse-power-minute.

The heat consumption of the 250-HP. Belgian compound engine per brake horse-power at the highest superheating of 307° F. is 220 thermal units. The turbine, therefore, probably holds the record for brake horse-power economy over the piston engine for superheated steam by a margin of about 3%, although had the compound engine been of the same horse-power as the turbine, so that its friction load would be only 8% of its power instead of the 13% here allowed, it would have excelled the turbine in brake horse-power economy by a margin of about 2.5%.

THE SULPHUR DIOXIDE ADDENDA.

The most economical piston engines, which, as we have seen, expand steam about 30 times, release their steam at the end of the stroke at about 6 lbs. absolute pressure, but they exhaust into a condenser, which, with a vacuum of 28 ins., contains a pressure of about 1 lb. absolute per square inch. If the expansion could continue until the pressure of 1 lb. was attained before exhaust occurred, considerable more work could be obtained from the steam. This, however, cannot be done in piston engines, for two reasons; first, because the low cylinder would have to be about five times greater in volume, which is commercially impracticable; and, second, because the velocity of exit through the largest exhaust ports possible is so great that the frictional resistance of the steam makes the back pressure from 1 to 3 lbs. higher than the condenser pressure in the best engines of ordinary piston speed.

All the work due to this extra expansion can be obtained, however, by exhausting the steam from the low cylinder at 6 lbs. pressure, against a nest of tubes containing liquid sulphur dioxide, which thereby is boiled to a vapor of about 170 lbs. pressure. This can be used to drive the piston of a separate engine or an extra cylinder attached to the main engine, and be thence exhausted into a condenser to be reliquefied. If the sulphur dioxide expands in its cylinder to a pressure corresponding to its temperature of liquefaction, and the latter is that of steam at 1 lb. pressure, the work derived from the fluid is the same as the extra work which the steam would have furnished in the main cylinder by continuing to expand to 1 lb. pressure and exhausting against 1 lb. of constant back pressure. The greatest vacuum required in this system does not need to be more than 20 ins., which is very easily produced and maintained, as compared with a vacuum of 28 ins., corresponding to 1 lb. of absolute pressure.

Professor Josse, of Berlin, has perfected this sulphur dioxide system of improvement, and reliable tests have shown that if cooling water of 65° F. is available, and to the extent of about twice the quantity usually employed for condensing steam under 28 ins. of vacuum, a sulphur dioxide cylinder of about half the size of the high pressure cylinder of a compound engine will do sufficient work to improve the best economy of such engines at least 15%. The steam turbine expands its steam to the pressure of its exhaust chamber, and as unlimited escape ports can be provided from this chamber to a condenser, it follows that the turbine can practically expand its steam to the pressure of the condenser. Therefore a steam turbine attached to a piston engine to operate with the latter's exhaust should effect the same saving as the sulphur dioxide cylinder, and turbines are being applied for this purpose at present by the makers of the Rateau type.

The turbine, therefore, even at this early period of its history, is already a formidable competitor to the piston steam engine in its most economical degree; and that it is so is mainly due to the fact that with no more waste in its steam action from internal friction than is due to the cylinder-wall wastes of the piston steam engine which are absent in the turbine, it more completely realizes the expansive principle enunciated in the infancy of steam history as the fundamental factor of economy, by its sagacious founder, the immortal James Watt.

THE PHILADELPHIA FILTRATION SYSTEM.*

Structural Details.

In designing the four filter plants constituting the Philadelphia filtration system, the desirability of uniform structural details was kept constantly in sight. It was of course impracticable to maintain absolute uniformity. As the work progressed, experience naturally suggested the desirability of certain structural changes, and these were made in the succeeding work. Furthermore, varying conditions at different plants and in different parts of the same plant called for modifications of the standard construction. In considering the structural details of the several filter plants it will, therefore, be sufficient to select a representative example from one of the plants, and to refer briefly to such changes as were made at other plants.

RESERVOIRS.

At two of the filter plants use was made of existing storage reservoirs for sedimentation purposes; at the Belmont plant a special sedimentation reservoir was constructed and at the Torresdale plant sedimentation was not provided for, but a regulating and compensating clear water reservoir was constructed at Oak Lane. The Belmont and Oak Lane reservoirs are, therefore, the only reservoir work that calls for mention.

BELMONT RESERVOIR.—The Belmont reservoir walls are rolled earth embankments 18 ft. wide on top and 134 ft. thick at the toe level of the inner slope. Around the top inside edge of the embankments there is a concrete curb wall and the sides and bottom of the basin are lined with 18 ins. of clay puddle on which is a 6-in. course of concrete surfaced to within a vertical depth of 10 ft. from the water line, with a ¾-in. coat of asphalt, asphalt mastic and grit.

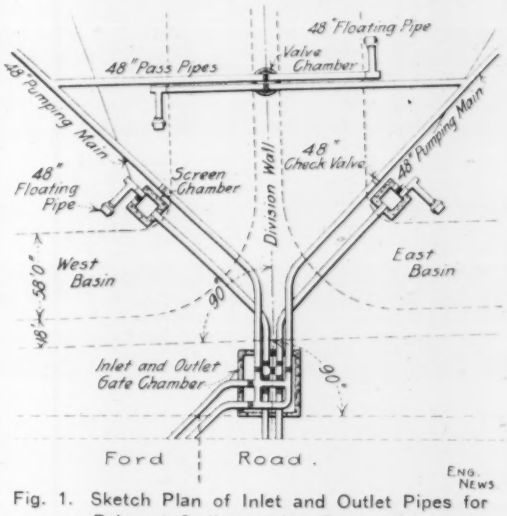


Fig. 1. Sketch Plan of Inlet and Outlet Pipes for Belmont Sedimentation Reservoir.

shown in Fig. 1 are 48-in. cast iron pipes, and the valves are all 48-in.-Ludlow stop valves, each provided with a compound geared gate stand and extension stem to operate from the gate house floor above.

OAK LANE RESERVOIR.—In its general construction the Oak Lane reservoir resembles the Belmont reservoir; the walls are earth embankments with concrete curb walls and both basins are lined with puddle, concrete and asphalt. Fig. 2 is a section showing an outside embankment and a portion of the floor. It will be noted that the floor is a series of inverted groined arches, this construction being adopted to allow of piers being set up and the reservoir roofed over in case roofing seemed desirable at any time in the future. The division wall between the two basins is pierced at two points by 36-in. pass pipes controlled through a valve well at the center of embankment. Fig. 3 is a transverse sectional elevation showing the embankment valve well and pass pipe construction.

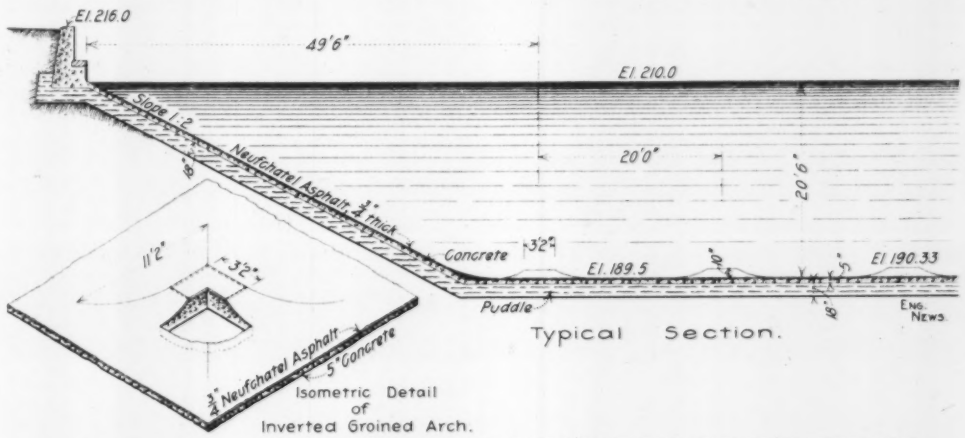


FIG. 2. PART SECTION OF OUTSIDE EMBANKMENT AND FLOOR, OAK LANE RESERVOIR.

The detail of most interest in connection with the reservoir construction is the arrangement of the inlet and outlet pipes and their control. This is shown by the sketch plan, Fig. 1. The inlet pipes reach diagonally across the respective basins, and each terminates in 14 tees and an elbow, with the branches turned slightly up from the horizontal. They are supported on brick piers 3 ft. × 13 ins. in size, spaced one to each pipe length and set on the concrete lining. Pass pipes through the division wall connect each inlet pipe with the opposite basin. At the free end of each pass pipe there is a swiveling tee mounted in bronze bearings. To the leg of the tee there is connected a galvanized iron pipe, whose free ends is supported by a float that keeps the pipe mouth always submerged a foot or two below water level. Similar floating pipes admit the water into the screen chambers and thence to the outlet pipes; there was also three sluice gates in each screen chamber through which the water may be drawn directly if desired. All the pipes

PRELIMINARY FILTERS.

The structural details of the preliminary filters call for only brief mention. At Belmont the preliminary filters were plain rectangular basins set side by side in two batteries of ten basins, each with walls and floors of plain concrete set in a layer of clay puddle. The preliminary filters at Lower Roxborough consisted of eleven basins set side by side and a cross section of one of the basins is shown by Fig. 4. It will be noted that the walls and floor are reinforced. Another point that needs to be noted is the arrangement for compressing the sponge mattress forming the topmost layer of filtering material. At both Belmont and Lower Roxborough the preliminary filter beds are housed in.

*Preceding articles on the Philadelphia Filtration System have appeared in Engineering News of Aug. 18 and Dec. 1.

PLAIN SAND FILTERS.

For the plain sand filters a uniform design and uniform structural details were adopted for all plants. At all plants the filters were arranged side by side in groups, and in all but the Belmont plant the filters of each plant are identical in dimensions. At Belmont and at Lower Roxborough the various filters are at different levels, but at the other two plants they are all at the same level.

COLLECTORS.—The design of the collectors for the filter basins was in process of evolution. The first form of main collector used at Lower Roxborough, which was the first plant to be built, consisted of a depressed channel in the floor concrete and of uniform size and shape from end to end. This channel was 24 ins. wide with semi-circular bottom and vertical sides, covered with reinforced concrete slabs set with their tops flush with the main floor level. The terra-cotta laterals connected at the main lateral with the arms of a special tee whose leg projected downward through a hole in the slab of the main collector. The sharp angle made with the floor by the side walls of the channel resulted in cracks. To avoid this trouble the whole width of the middle bay was depressed and a 30-in. terra cotta main was laid therein with special connections for the laterals. This construction was used on two of the Belmont filters, as well as at Lower Roxborough, but it did not prove wholly satisfactory. The next construction adopted was a rectangular channel, formed by two side walls, set in the basin floor and covered with reinforced concrete slabs. The side walls were set 4 ft. apart in the clear and were 16 ins. high, with a vertical inside face and a new face with a 3-in. bottom. The average thickness of the walls was 13½ ins., and the covering slabs were 5 ins. thick, provided with two lifting rings and had the joints sealed with strips of burlap dipped in asphalt. The lateral collectors passed through holes in the sidewalls. This construction was adopted for all the remaining filters. The lateral collectors in all cases were 8-in. terra cotta pipe perforated all around with small holes, but having tight joints and plugged ends.

SAND RUNS.—Each filter basin is provided with an entrance and an elevated sand incline and run for its full length. This entrance is formed by raising the roof of the center longitudinal bay, as shown by the drawings of Fig 7, and providing a doorway in the front wall. Beginning at the sill level of this doorway a platform descends into the basin on an incline for 46 ft. 7 ins., and then on a level grade to the opposite end of the basin. To form this platform I-beams, with their ends set into the concrete piers span the bay and carry two pairs of channels, which carry plank runways. This platform construction is shown in detail by the drawings of Fig. 8, and was practically the same for all filters except for dimensions due to variations in the sizes of the basins and for the use of wooden joists instead of steel channel joists to carry the planking.

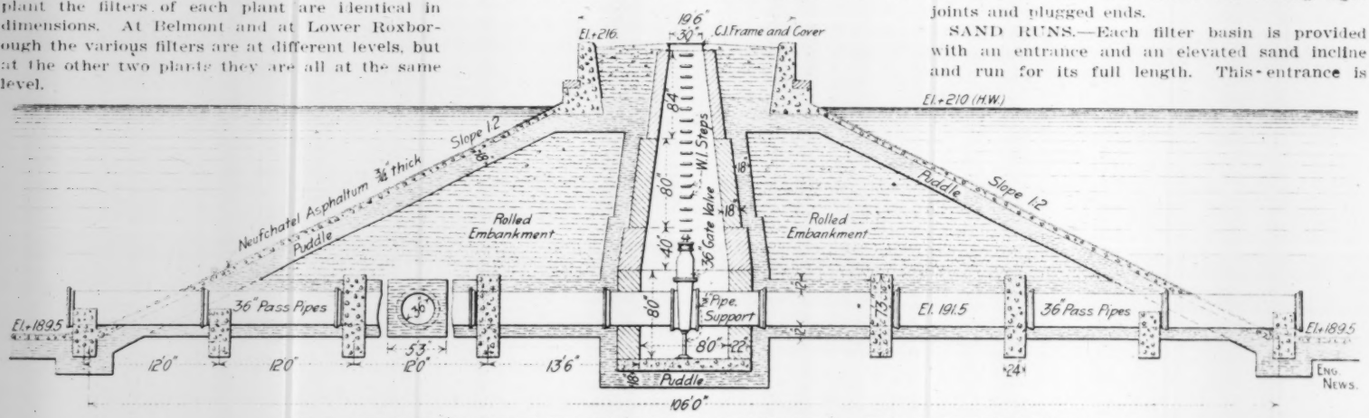


FIG. 3. SECTION OF INSIDE EMBANKMENT AT VALVE WELL, OAK LANE RESERVOIR.

FILTER BASINS.—The outside walls and the division walls between adjoining filter basins are of concrete; the floor consists of inverted groined arches of concrete on which stand the columns that support the roof which consists of groined concrete arches. The roof columns or piers are spaced 15 ft. 3 ins. apart c. to c. in both directions for the Belmont filters and 15 ft. 10 ins. apart at the other filters. This spacing determines the sizes of the vaulted roof and floor arches. A layer of clay puddle underlies the floor and turns up along the outside walls to the height of the springing line of the roof arches. Lengthwise of each filter at the center is a main clear water collector, which near the front of the basin has a right angle bend to connect with the regulator house, located on the center line of adjoining filters and serving both.

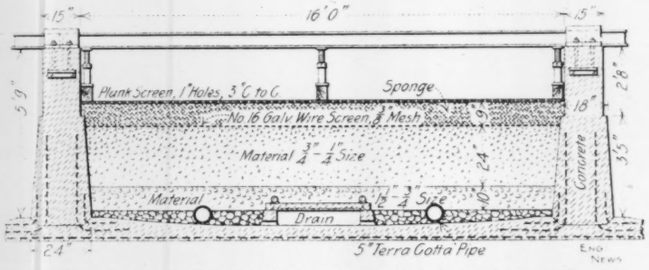


FIG. 4. CROSS-SECTION OF PRELIMINARY FILTER BASIN, LOWER ROXBOROUGH.

The drawings of Fig. 5 show two sections of one of the filter basins at Belmont. All dimensions are given, and the other points to be noticed are the side wall and division wall construction; the roof covering and drain pipes, and the ventilators. The side walls were designed as abutments to resist the thrust of the arches. The ventilators are located at the crowns of alternate vaults. The two filter basins, parts of which are shown in Fig. 5, are located in the same level. Where adjoining basins are located at different levels a slightly different construction is necessary at the point of junction, and this is shown by Fig. 6, which is a detail from the Lower Roxborough plant. The drawings of Figs. 5 and 6 serve to explain the basin construction of all the filter beds, the only changes being of minor character.

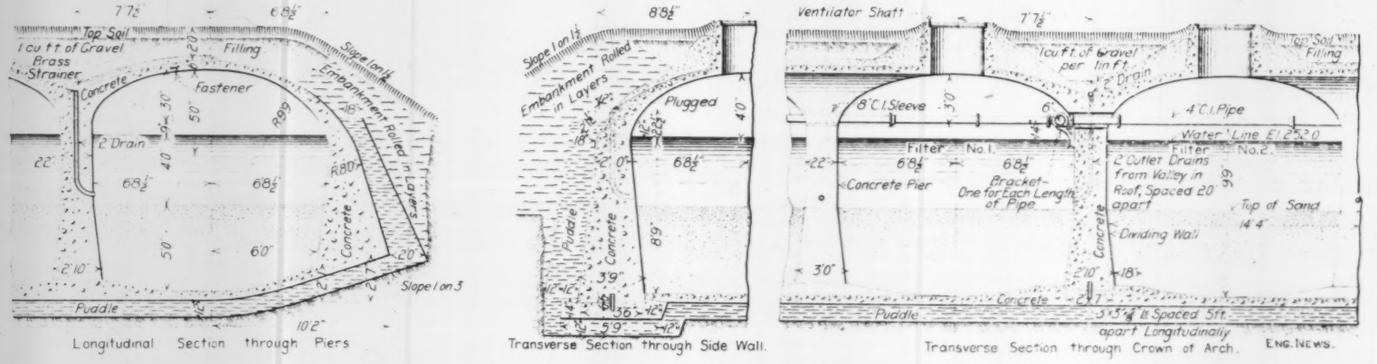


FIG. 5. PART LONGITUDINAL AND TRANSVERSE SECTIONS OF PLAIN SAND FILTER BASINS.

Plan 1 requires the least amount of gravel, but is most expensive for labor in placing and plan 3 requires the largest amount of gravel, but is least expensive for labor of placing. The engineers state that so far as experience at Philadelphia has shown neither plan has any superiority over the others. Plan 1 is considered the ideal one since no water that passes down between the

walls or piers and the sand can get to the gravel underdrain without passing laterally through the sand fill around the piers and against the walls.

The sand bed over the gravel underdrain is nominally 36 ins. thick, but in placing the sand in a series of beds the depth is varied in order that the time of going out of service of the filters for resanding may not occur at the same time for more than one or two filters. Thus, at the Belmont plant the sand bed was made 28 ins. deep for three filters and 31 ins., 34 ins., 37 ins., 40 ins. and 43 ins., deep for three filters in each case. It should be noticed that the depths given are those of the settled beds; when first placed the depths are about 6% more than the depths given. In the thin beds the sand is placed in two layers, and in the thick beds in three layers.

REGULATING CHAMBERS.—The regulating chambers in which are located the devices for controlling the influent and effluent of the filters are of two kinds and may be designated as double and single chambers. The double chambers each control two filters, and the single chambers control one filter each. At Lower Roxborough single chambers are used for all filters, but at the other plants double chambers are used in all but a few cases when special conditions required a single chamber for each filter. The typical double chamber arrangement is shown by the drawings of Fig. 9.

As will be seen from the plan the chamber is divided into three compartments, a center or inlet compartment and two side or outlet compartments, one for each of the two filters served. Considering the inlet compartment first, it will be seen from the plan that two supply pipes pass through it into the two filters, and three terminate in a regulating valve. The nature of this valve is best shown by the section C. D. It consists of a plain double seated disk valve, nearly balanced, actuated by a copper float. By the rise and fall of the float in the water in the filters the valve is closed or opened and the rule of inflow of run water thus regulated so as to maintain a nearly constant level. The engineers point out that this influent valve is in all material respects a copy of the influent regulators at the Hamburg filters. It will be noted that the illustration shows a direct operated valve. In some of the filters the valve is actuated by a float operating through a walking beam arrangement.

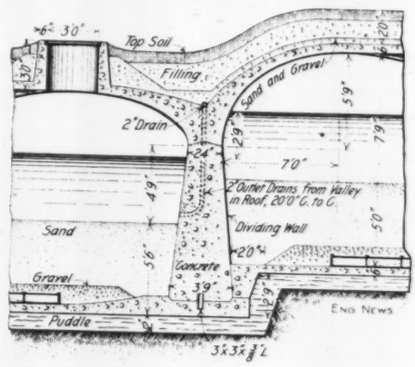


Fig. 6. Section Showing Junction of Filter Basins Located at Different Levels.

The arrangement adopted is shown by Fig. 10, which is a detail from the Torresdale plant.

Turning now to the outlet regulators reference need be made only to one as all are of the same construction. The plan and section E E F F of Fig. 9 show the construction. The main collector from the filter discharges directly into the concrete well forming a side compartment of the regulating chamber. Upon the main effluent pipe where it starts in the compartment is placed an automatic telescoping circular weir, controlled in position with reference to the surface of the water in the compartment by an annular copper float. This self-adjusting weir has its lip fixed at a definite depth below the surface of the water, and this depth may be changed at will by means of the rod and hand wheel shown.

In the early form of the effluent weir the telescoping joint was made with a water packed bronze gland, but experience showed that it is impossible to produce drawn-brass pipes 20 ins. in diameter so round or uniform in diameter as to admit of the use of the packing described, and a leather packing which will readily adjust itself to the eccentricity of the sliding tube and to the inequalities of diameter, has been substituted for the bronze ring. These leather packings have worked admirably. Some trouble was experienced from air which was drawn into the column of water descending the telescoping pipe and to remedy this defect the neck at the top of the fixed barrel was tapped with a pipe reaching above the highest possible water level in the chambers. The entrained air is vented through this pipe.

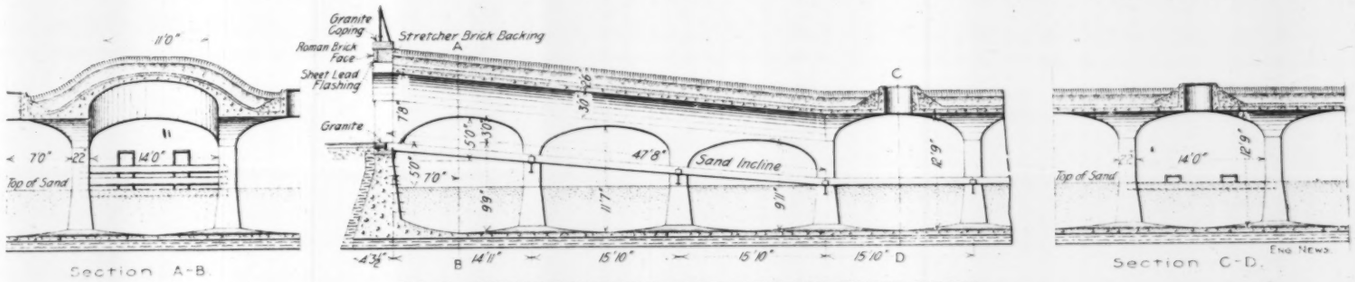


FIG. 7. SECTIONS SHOWING SAND RUNS FOR FILTER BASINS.

CLEAR WATER BASINS.

The clear water basins for the several filter plants are constructed exactly alike except, of course, for the main lateral dimensions, and their construction resembles closely that of the filter basins, viz., concrete side walls, a floor of inverted vaulted arches carrying piers which support a roof of vaulted arches. Two sections of the clear water basin at the Belmont plant are shown by Fig. 11. One of the chief points to be noted is the use of puddle to fill the depressions formed by the roof vaults and the system of roof drains to keep all rain water from getting into the basin. The other details and dimensions are given clearly by the drawings. Inlet and outlet chambers are provided for each basin. The inlet arrangement is practically the same as that described for the filters, that is a disk valve operated by a float riding on the surface of the water in the basin. The outlet devices differ somewhat at different plants but are always plain pipe and gate valve arrangements.

PIPES AND CONDUITS.

The system of pipes and conduits appurtenant to the filters differ in details of arrangement and construction for each filter plant. Generally, it consists of an influent pipe to supply water to the filters, an effluent pipe to conduct away the filtered water, a refill pipe, a raw water drain pipe, a pressure pipe and one or more sewers. The typical arrangement at the Torresdale Filters is shown by the drawings of Fig. 12. The direction of flow in the main influent and effluent pipes is indicated by the arrows, and the part plan and section shown may be co-ordinated with the whole plant by reference to the general plan of the Torresdale Plant, published in our issue of Aug. 18, 1904. The cast-iron and tile conduit construction present nothing unusual, and all the conduit work at Belmont and the two Roxborough plants was of cast-iron and tile. At Torresdale, however, use was made of considerable concrete-steel conduit, and this being comparatively unusual, may be described briefly. The general arrangement of the work is shown by the sketch plan, Fig. 13. The effluent from the filters flows in cast-iron mains, increasing from 36 ins. to 60 ins. in diameter, laid on each side of the courts which discharge into the collecting clear-water conduit laid along State Road. The water from this conduit flows into the clear water basin, or may be by-passed around it. A 10-ft. conduit connects the clear water basin with shaft No. 1 of the Torresdale conduit. All these conduits were of concrete, reinforced by expanded metal, and their construction is clearly shown by Fig. 14. The main sewers, as shown by Fig. 13, run south through the center of the plant and empty into Pennypack Creek. Only the 6-ft. and 8½-ft. sizes are built of concrete, and the 8½-ft. sewer alone is reinforced. The drawings of Fig. 15 show the sewer construction. The method of constructing these conduits is described in a succeeding article.

SAND WASHERS AND EJECTORS.

The number and location of the sand washers for each filter plant were given on the plans published in our issue of Aug. 18, 1904. The type of washer employed is that known as the Schroeder washer or ejector washer, and the particular construction employed is that shown by Fig. 16. A pyramidal cast-iron hopper, provided with a sprinkler pipe, is set over an ejector. The dirty sand is placed in the hopper, where it is wetted by the sprinkler pipe, and is gradually sucked out by the water stream of the ejector. The delivery pipe of the ejector discharges the mixed sand and water into an inclined trough, which discharges into a second hopper, whose

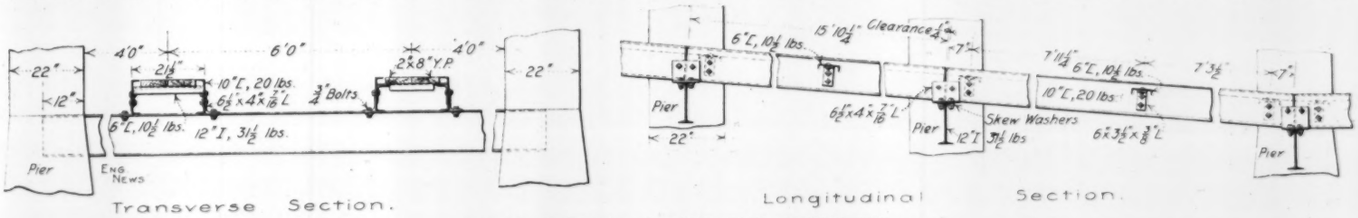


FIG. 8. DETAILS OF SAND RUN PLATFORMS.

ejector feeds it into a third trough and hopper, and so on. The dirty water overflows the sides of the hoppers, and is carried away, and the clean sand and water from the final hopper is discharged into the clean sand piles. The arrangement of a series of hoppers and their appurtenances is shown by the drawings of Fig. 17. These handle as much sand as will 20 men with wheelbarrows, and, furthermore, that about one-half of the washing has been accomplished by the time the sand reaches the washers.

MATERIALS OF CONSTRUCTION.

The principal structural materials employed in building the Philadelphia filters were puddle, concrete and asphalt. There were used, of course, in the aggregate large quantities of steel, brick and stone masonry, cast iron and tile pipe and valves and valve fittings of various sorts, but with few exceptions these were of standard material and forms and do not, therefore, call for particular mention. Because of the enormous quantities of concrete and puddle that were used and the importance of their structural applications, however, a brief review of the character demanded of these materials is desirable.

pug mills, and was rolled in place in thin layers. Its composition was 50% by volume of clay and 50% of ballast, which was either broken stone or clean gravel. Generally the clay consisted of equal parts of a strong, heavy, ferruginous clay from Perth Amboy, and Brunswick, N. J., or from Charlestown, Md., and of a weak clay combined

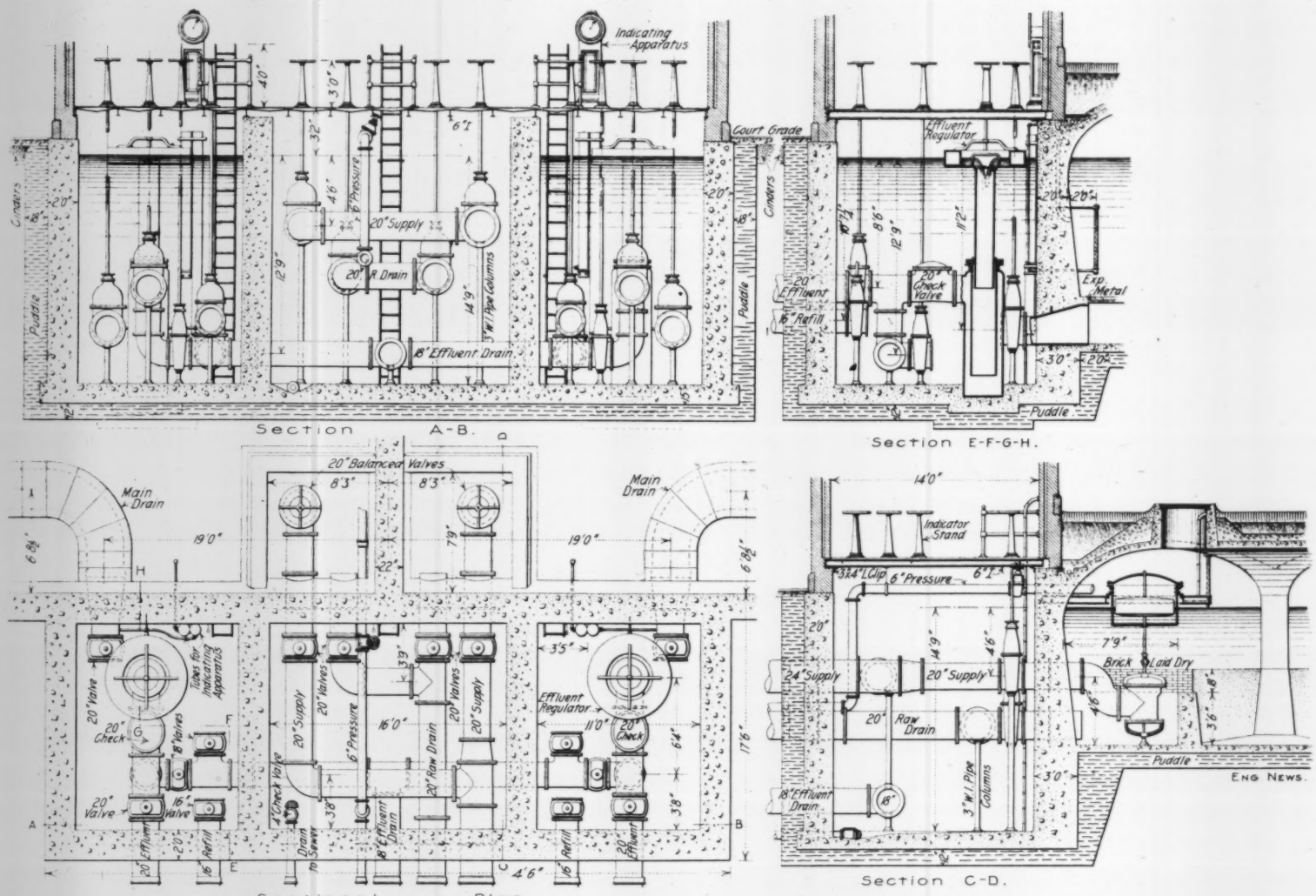


FIG. 9. PLANS AND SECTIONS OF DOUBLE REGULATING CHAMBERS AND APPLIANCES.

drawings show the washers at the Upper Roxborough filters. From the main pressure pipe A, five branches, B, C, D, E and F, lead to the ejectors of hoppers 1, 2, 3, 4 and 5. The ejector discharge pipes, B1, C1, D1, E1 and F1, lead to the troughs b, c, d and e, and to the clean sand pile, respectively. The sprinkler main is shown at G, and the sprinkler pipes at g g, etc. In operation the sand from the portable ejector inside the filter bed is fed to the trough a, and thence through the several hoppers and troughs to the delivery pipe F1.

The construction of the most essential parts of the washers is shown by Fig. 16, in which the principal points to be noted are the horizontal arrangement of the ejector nozzles and the provision of removable nozzle tips where the wear is greatest. The troughs are of plain sheet metal construction with baffle plates on the bottom. Each hopper also has one edge cut down to form a weir for the discharge of the dirty water.

The construction of the portable sand ejectors is shown by the drawings of Fig. 18. This device, as shown, consists of a Koerting ejector mounted in the bottom of a conical metal hopper. Two lines of water pipe are connected by ordinary fire hose, with the nozzle and throat extensions, one to supply water under pressure to operate the ejector and the other to conduct the mixed sand and water from the ejector in the washer located in the court outside the filter. The water is brought to the ejector through 2½-in. line of hose and the mixed sand and water is taken to the washers through a line of 3-in. hose. Each ejector weighs about 160 lbs., and will handle from 6 to 8 cu. yds. of sand per hour. It has been found that an ejector and three men will

with small gravel obtained from Swedeland, Pa. The purpose of the weak clay was to temper the heavier material so that it could be readily worked in the pug mills. The ballast generally was broken stone ranging in size from ¼ in. to 1½ ins. In a few instances the two clays and the ballast were mixed in equal parts.

The strong clay by rational analysis showed by weight from 60% to 70% silicate of iron and alumina and the weak clay showed from 35% to 40% silicate of iron and alumina. The mixture.

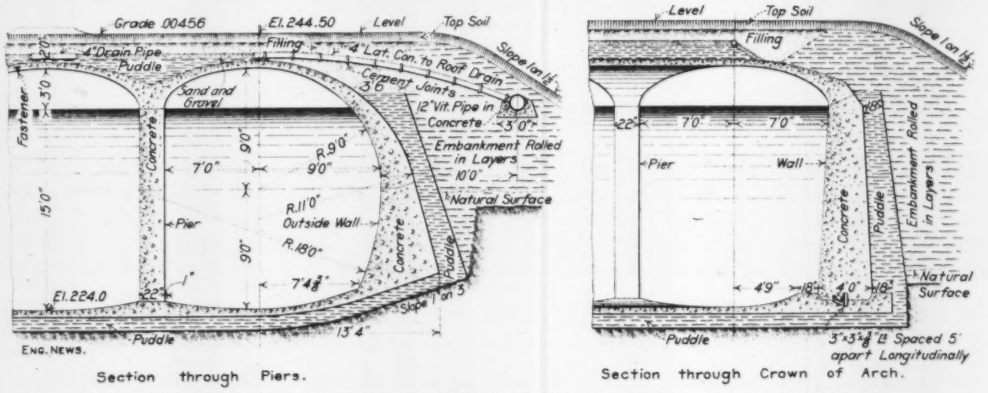


FIG. 11. SECTIONS SHOWING CONSTRUCTION OF CLEAR WATER BASINS.

CLAY PUDDLE.—The chief reliance for water tightness of the various reservoirs and filter basins is placed in clay puddle, a layer of which surrounds each structure on sides and bottom. This puddle was of the same general composition for all four works, was specially manufactured in

usually yielded in analysis about 50% of silicate of alumina and iron and 50% of silica and other invaluable substances. Using equal parts of clay and ballast gave a matrix for the ballast about 25% in excess of the voids in the mass of hard material. Water was added in sufficient quanti-

ties to make a plastic mixture, and this was placed in 6 to 9-in. layers and rolled to a thickness of from 4 to 6 ins. When rolling was completed the puddle was as solid and almost as hard as new concrete.

CONCRETE.—Practically all the concrete used was 1-3-5 mixture of Portland cement, cleaned sand and gravel or broken stone. Six-inch concrete cubes were molded from day to day, and tested at the ages of one, two, three, four and six months. When a cube showed a crushing strength at three months of less than 1,500 lbs. per square inch the work into which the corresponding mixture had been put was drilled into to determine its hardness and density. This resort was very rarely required and in no case did the examination give results that indicated any doubt of the quality of the concrete. Generally the tests at 90 days and older gave a crushing strength exceeding 2,000 lbs. per sq. in.

The cement for concrete work was furnished under the following conditions:

Specific gravity not less than	3.1
Retained on No. 50 sieve	0%
" " " 100 "	10%
" " " 200 "	25%

Initial sit (Vicat needle) not less than 20 mins. Tensile strength of 1-3 briquettes, 7 days, 170 lbs.; 28 days, 240 lbs.

The average tensile strengths shown by test were 200 lbs. per seven days and 300 lbs. for 28 days. No cement that failed to give the required strength at seven days was allowed to go into the work for 28 days, and if it then failed to pass the 28-day test it was rejected. The sand used in the manufacture of the concrete was clean New Jersey bank sand, and the stone varied in size from 1 in. to 1½ ins., and was screened of all finer materials. The proportion of mixing water varied from 15¼% to 18½% of the cement, sand and ballast by volume. With the exception of the piers in one filter all concrete was rammed and finished in place.

ASPHALT.—To ensure as perfect water tightness as possible for the sedimentation reservoir it was coated with two ⅜-in. layers of asphalt. Two mixtures of asphalt were used as follows: For the floor and first layer in the slopes, 585 lbs. Seyssel mastic, 315 lbs. grit, 50 lbs. refined Trinidad asphalt, and 50 lbs. refined Bermudez asphalt; and for the second layer in the slope, 598 lbs. Seyssel mastic, 332 lbs. grit, 33 lbs. refined Trinidad asphalt and 37 lbs. refined Bermudez asphalt. These mixtures gave respectively about 15.5% and 13.2% of bitumen. At first a mixture containing 18% bitumen was tried, but it was found to be too soft for the slope work.

PROBABLE WIND PRESSURE INVOLVED IN THE WRECK OF SMITH AVENUE BRIDGE AT ST. PAUL.*

By C. A. P. Turner,† M. Am. Soc. C. E.

In view of the fact that the wreck of a well-braced iron or steel structure by wind is exceedingly rare, if, indeed, there is any previous record of such, the destruction of part of the so-called High Bridge over the Mississippi River at Smith Ave., St. Paul, Minn., on Aug. 20, 1904,‡ would seem to be of special interest to the professional bridge engineer.

This structure was designed supposedly to meet with a reasonable factor of safety, the maximum wind loads required by a standard specification; and the utter destruction of a portion of it by wind pressure alone, in view of this supposed margin of safety, would lead to the presumption that the standard requirements do not produce a safe structure, unless it can be shown by reasonable computation that there was some weak joint or detail in the frame which would insure its destruction under the action of forces not materially greater than those which, nominally, it was designed to withstand.

The structure was built in 1887 according to general plans prepared by the City Engineering Department of St. Paul. Detailed drawings were made by the contractor, C. L. Strobel, M. Am. Soc. C. E., and the work was erected by Horace E. Horton, M. Am. Soc. C. E., of Chicago, Ill.

The bridge is a deck structure of wrought iron, 2,770 ft. long, and runs northwest and southeast. The northwest portion of the bridge is of the viaduct type, with riveted spans of 80 ft. and plate-girder tower spans of 40 ft. Four-leg towers alternate with two-leg bents. The portion of the viaduct over the river consists of four 250-ft. pin-connected deck spans of the subdivided Warren type, 30 ft. deep and 22 ft. from center to center of trusses. The floor beams are at 12 ft. 6 ins. on centers. The tower supporting the shore end of the southeast 250-ft. span has a base of 55 ft. transversely, and of 50 ft. longitudinally, and a height of 129 ft. from the top of the pier to the bottom chord of the truss. As these trusses were 30 ft. deep, the roadway at this point was 160 ft. above the pier and about 180 ft. above the water. From this tower toward the bluff there was one 170-ft. pin span and two 60-ft. plate-girder spans.

These girder spans, the 170-ft. pin span, the supporting tower, and the first 250-ft. span at the southeast end were overthrown.

The bridge carries a 25-ft. roadway and two 8-ft. walks. The flooring for the roadway consists of a sub-floor of 3¾-in. fir plank and a wearing floor 1¼ ins. thick. The plank for the walks is 2¾-in. pine. The stringers are of steel, the roadway of nine lines of 12-in. built stringers, with flanges each of two 2 × 2 × 5/16-in. angles, and 5/16-in. webs; the stringers for the walks are 6-in. I's.

The trusses were designed for a live load of 80 lbs. per sq. ft. for the roadway and for the walks of the 250-ft.

*A paper read before the American Society of Civil Engineers on Dec. 7, 1904. Reprinted from "Proceedings of the American Society of Civil Engineers," Vol. XXX., No. 9, pp. 794-799, "Probable Wind Pressure Involved in the Wreck of the High Bridge over the Mississippi River on Smith Avenue, St. Paul, Minn., August 20, 1904."

†Consulting Engineer, 816 Phoenix Building, Minneapolis.

‡See a description of the havoc wrought by this storm, with many photographic views, in Engineering News of Sept. 1, 1904, pp. 192-196. The article also gave full particulars of the wrecked Smith Ave. bridge, and four views of its ruins. See also a letter of R. A. Tanner, giving some important further information about the wreck of this bridge, in Engineering News of Oct. 27, 1904, p. 385, which is amplified by a letter printed in the correspondence columns of the present issue.

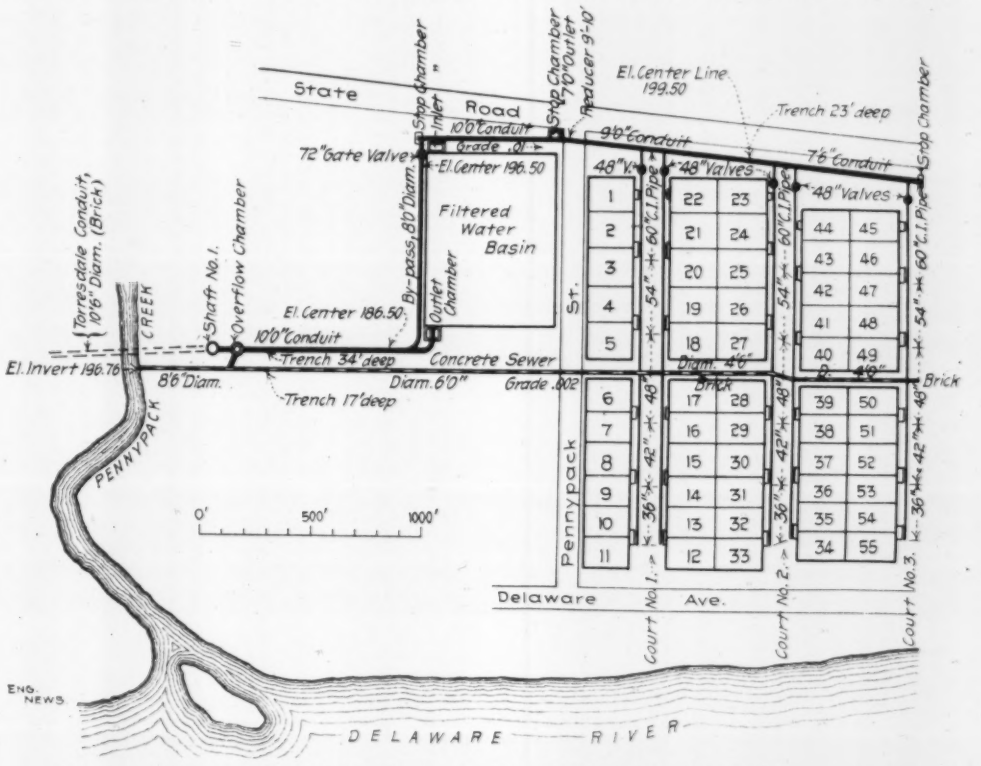


FIG. 13. SKETCH PLAN OF CONCRETE-STEEL CONDUITS AT TORRESDALE FILTERS.

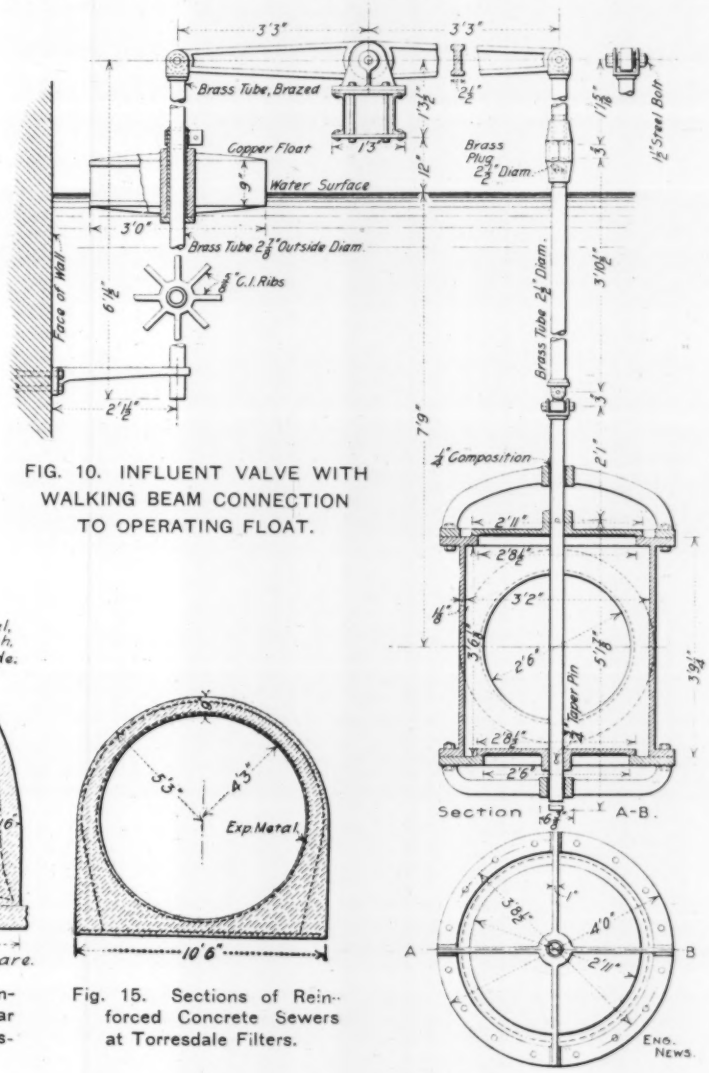


FIG. 10. INFLUENT VALVE WITH WALKING BEAM CONNECTION TO OPERATING FLOAT.

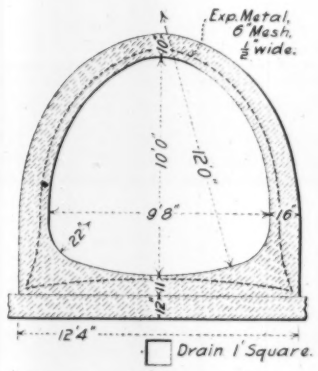


Fig. 14. Sections of Reinforced Concrete Clear Water Conduit at Torresdale Filters.

Fig. 15. Sections of Reinforced Concrete Sewers at Torresdale Filters.

spans, 90 lbs. for the 170-ft. span and 100 lbs. for all shorter spans.

The lateral bracing was designed for a pressure of 450 lbs. per lin. ft. of bridge, two-thirds of which was assumed to act on the loaded (upper) chord. The towers and bents were assumed to have a wind pressure of 150 lbs. per lin. ft. acting against them.

In addition to the top and bottom lateral systems, a fairly efficient system of sway rods was provided in the 250-ft. span, and all the details of the lateral and sway bracing seem to have been well worked out for the type of bracing used.

The conditions after the storm are about as follows: The 250-ft. span is lying on its side, except at the end torn from its support on the two-leg bent (still standing), and this end has been given a quarter twist in addition; this span, and the 170-ft. shore span, have fallen or have been blown a considerable distance from the tower. The plate-girder spans seem to have been pulled down the bank, and are but little out of the line of the viaduct. The tower frame which was overthrown was badly twisted, and the position in which the columns fell, together with the manner in which the bolts were bent and broken, would seem to indicate that the end of the 250-ft. span resting on the two-leg bent was first pushed off its support, and that the wind, acting on the loose span with its 10,000 or 11,000 sq. ft. of exposed area (the planking was well fastened) and an extreme leverage of 250 ft., twisted from its base the tower bent supporting the other end, and the falling mass, in its descent, pulled the girder spans down the hill.

If the collapse occurred as outlined, a few figures on the twisting moment on the top of the tower may be in order. Supposing the floor to be at such an angle to the wind that the effective pressure is, say, 10 lbs. per sq. ft., then the twisting moment = 10 × 10,000 × 125 ft. = 12,500,000 ft-lbs., an amount far in excess of the ultimate resistance of the tower.

The next point which would seem to invite attention is the detail of the connection of the end of the wrecked 250-ft. span to the two-leg bent, and the strength, or resistance of this connection to uplift and to lateral sliding of the shoe.

There is a two-leg bent, similar to the one that supported the end of the wrecked span, nearer the other shore, and, as this seat was easily accessible by a trap in the floor, a suspended platform and an iron ladder leading down to the shoe, it was examined first. The end of the 250-ft. span corresponding to that which was wrecked was found to rest on a nest of eight rollers each about 2⅞ ins. in diameter with the usual spacing bars on the sides. The sole resistance to the lateral motion of the rollers was a bar riveted to the cap on each side and a recess in the shoe above, about ½ or ⅝-in. in depth, as nearly as could be readily determined. Provision was made for a 1½-in. guard bolt on each side of the shoe, a hole was provided in the column cap and a long slot in the side of the shoe. *No bolts, however, were in place.*

In the corresponding bent on which the wrecked 250-ft. truss had rested it was found that this span was anchored down somewhat better than the one referred to above, and instead of having no bolts at all, there was one, on the outside of the windward shoe, which is splintered and broken in place. The appearance of the other three holes is positive evidence that there were no bolts in any of them.

Thus the resistance of this end of the span was reduced to the dead weight and the value of this one bolt. If the wind tended to raise the windward truss, as it is pin-connected with the eye-bar bottom chord and diagonals, the truss would furnish little resistance to upward forces, and the bolt at the end, being a cantilever 3½ to 4 ins. long from the center of the shoe plate to the center of the bearing in the cap, would not develop its shear value, but only its bending value, the insignificant amount of 3,000 or 4,000 lbs. or less. An uplift on the windward side would be accompanied by a reversal of stress in the bottom chord, the probable buckling of the chord, and with the slight resistance of the bolt, the shoe would be pulled from the cap and the rollers displaced. Actually, only one roller was left on the windward cap, while seven of the original eight remain on the leeward cap.

A rough approximate estimate of the weight of the span and floor would be in the neighborhood of 2,200 lbs. per lin. ft., giving a reaction of, roughly, 140,000 lbs. at each support. As the storm was a severe one, it will be assumed, for purposes of computation, that the very severe wind pressure of 30 lbs. per sq. ft. was acting at an upward angle to the floor of 30°, and the pressures will be calculated in accord with Unwin's table.

Let a = Angle of surface with direction of wind;
F = Force of wind, in pounds per square foot (assumed at 30 lbs. per sq. ft.);
A = Pressure normal to surface = F sin a $^{1.84 \sin a - 1}$;
C = Pressure parallel to direction of wind
= F sin a $^{1.84 \sin a}$.

For a = 30°, A = 0.66 and C = 0.33.

The direct uplift at each shoe = 20.5 × 125 × 0.66 × 30 lbs. = 50,100 lbs. from the wind on the floor.

The overturning force, C, at each end of the bridge = 0.33 × 30 lbs. × 41 × 125 = 51,200 lbs. from the wind on the floor.

The uplift from C on the windward shoe = $\frac{51{,}200 \times 30}{22}$ = 70,000 lbs.

The direct pressure on the side of the truss top chord, approximately, = 30 × 7 = 210 lbs. per lin. ft., and $\frac{210 \times 125 \times 30}{22}$ = 36,000 lbs., the uplift from the same.

As the wind has been assumed to be blowing upward, this component on the vertical area would give an additional uplift of some 6,000 lbs.

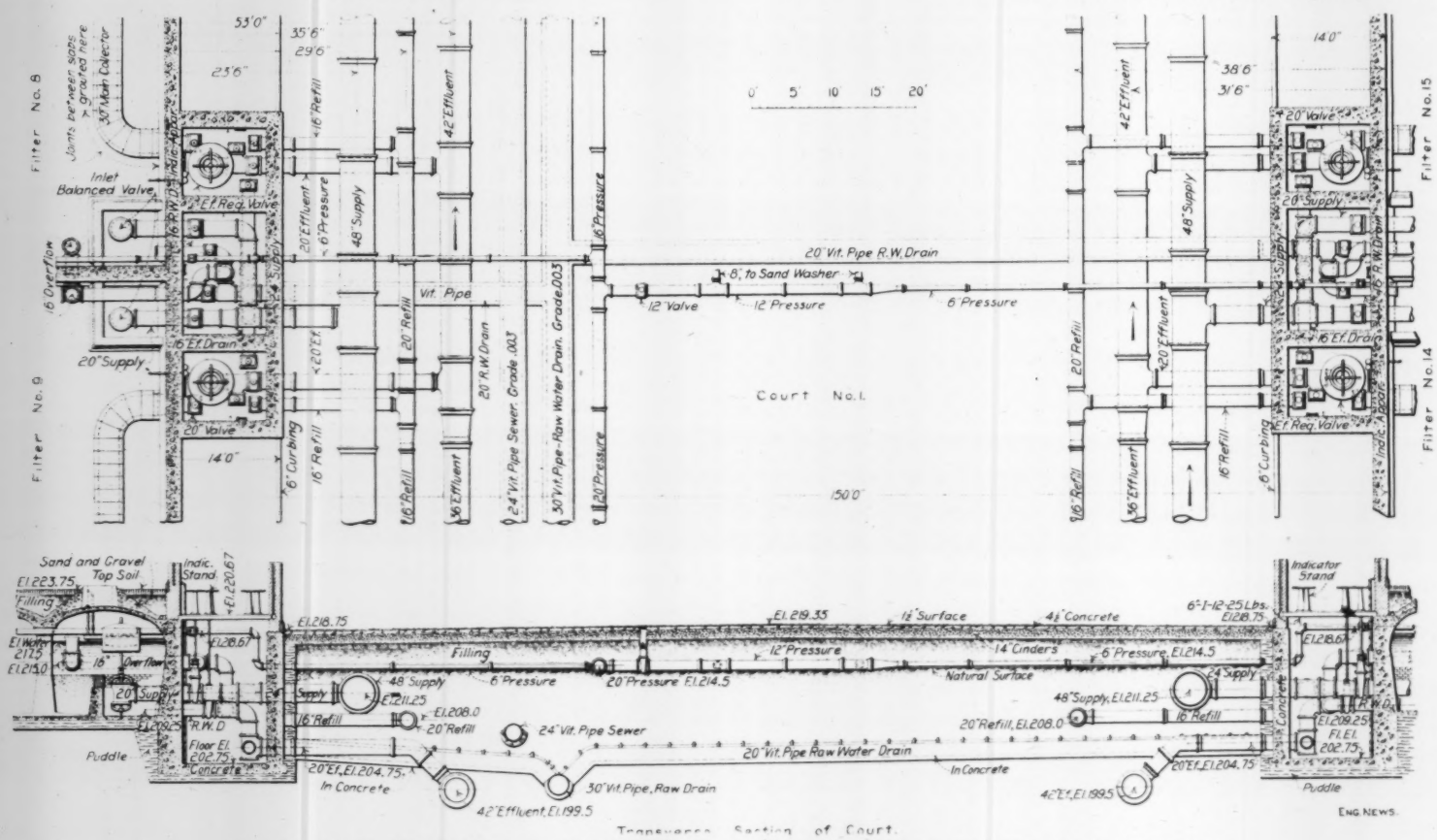
Now, the sum of these computed uplifts is 162,100 lbs., or about 15% greater than the reaction due to weight.

Evidently, if the windward shoe is raised, there being no bolts to hold down the leeward shoe, it would turn sufficiently for the recess in the shoe to clear the corner of the rolls and then slide off the cap.

Allowing some slight resistance for the expansion connection of the stringers to the beam, it would seem safe to conclude that the wind pressure assumed is 10% greater than would have been necessary to cause the wreck.

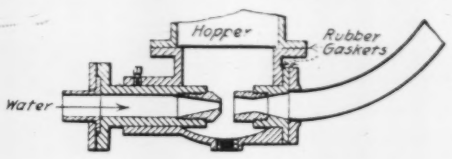
Rough computations on the laterals, taking into consideration the sway rods and the action of the four planes of bracing, would indicate that they were not strained much beyond 23,000 to 25,000 lbs. under the assumed forces.

Bearing in mind the fact that the floor is on a steep up grade, it may well be that the angle of action of the wind on the floor was greater than has been assumed, and, if so, the necessary pressure to cause the wreck might be considerably less than the 27 lbs. per sq. ft. calculated. Again, the probability is that the assumption of a uniform pressure is materially in error. Judging

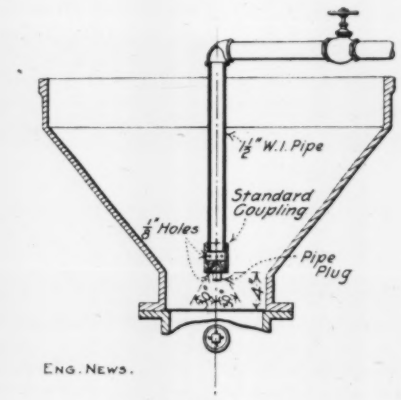


Transverse Section of Court.

FIG. 12. PLAN AND SECTION SHOWING TYPICAL PIPE ARRANGEMENT AT TORRESDALE FILTERS.



Nozzle and Ejector.



Sprinkler.

Fig. 16. Details of Sand Ejector.

somewhat by the contour of the bluff and the path of the storm, it would seem likely that the maximum pressure was in the vicinity of the northwest end of the wrecked 250-ft. span, and that the adjoining span was saved by its rigid connection to the two-leg rocker bent. If the pressure were greater at the end, it is evident that the average pressure necessary to cause the wreck would be materially less.

Such moderate pressures as have been figured on, when their cumulated effect is concentrated upon a weak detail, may evidently produce results that cause astonishment and the rash assumption, by those whose training should lend better judgment, that the pressures involved are "exceedingly great."

Evidently, whether dealing with bridges or roofs, stiff riveted construction, with bottom chords and diagonals capable of taking reverse stresses is to be preferred, and, in view of the fact that, by the exercise of reasonable skill in design, they can be fabricated for a sufficiently smaller cost than the pin type to offset the additional expense of riveting in the field, they should be preferred for all moderate spans, such as 250 ft. or less, unless the work is exceptionally heavy.

In the provision for temperature stress, the expensive and frequently weak detail often worked out to avoid a harmless little amount of temperature strain, in an effort to eliminate it entirely, is indeed surprising; perfect double-action joggle connections are too often introduced at the shortest possible intervals, and dignified by the name of expansion joints.

In the present instance, for example, an ordinary sliding plate fitted with a compression grease cup would probably move as easily as the badly rusted rolls on a rusty base and cap; while the guard bolts would be brought into actual shear and tension under forces tending to displace the shoe instead of in bending as with the detail adopted.

From a careful examination of the 2½-in. anchor bolts of the windward column of the fixed bent under the 250-ft. span, it would seem that they were without nuts, though this fact appears to have had no material influence on the wreck.

THE DUNDEE DAM ABOVE PASSAIC, N. J., was declared a nuisance by a grand jury in September, 1903, and accordingly the Dundee Land & Power Co. was indicted. The company appealed to the New Jersey Supreme Court to quash the indictment, but the court has just denied the motion. From the text of the decision it appears that the dam was built in 1859 under a legislative act of Feb. 12, 1858, which empowered the company to improve the navigation of the Passaic River between the mouth of Weasel Brook and some convenient point in the city of Paterson by building a dam at that point and a canal with locks, a towpath and other accessories around the dam. The company built the dam, as stated above, and built a canal, but did not make the canal of the stipulated dimensions (75 ft. wide at the water line and 4 ft. deep) and did not provide locks and a towpath. Because of these omissions, the court holds, the company has not only failed to improve the navigation of the river, the alleged object of its incorporation, but the dam has obstructed the navigation of the stream and has been and is a nuisance. If this prosecution, which is on behalf of the public, continues to meet with success in the higher courts (N. J. Court of Appeals and U. S. Supreme Court) it may be supposed, in view of the decision, that the dam will be removed. An alternative, we presume, is the completion of the canal and locks, either in accordance with the original act of incorporation or on a larger scale. In either event it is hoped by the city of Paterson that the U. S. Government will improve the navigation of the river from Passaic to Paterson, and that the banks of the stream between those points will be lined with industrial plants. Inasmuch as the fall at the Dundee dam is 22 ft. and some 1,200 HP. net is developed by the dam, it is not to be expected that it will be removed without a serious struggle. The fight against the dam was begun twenty years or more ago, but has been dropped from time to time through lack of funds or mysterious "influences." Latterly, Paterson has alleged that if the dam were removed with it would go all reasonable grounds of complaint against the discharge of the sewage of Paterson into the river, and thus there would be no need for at least the upper end of the proposed Passaic Valley trunk sewer. Altogether, therefore, the controversy over this structure involves many points of interest.

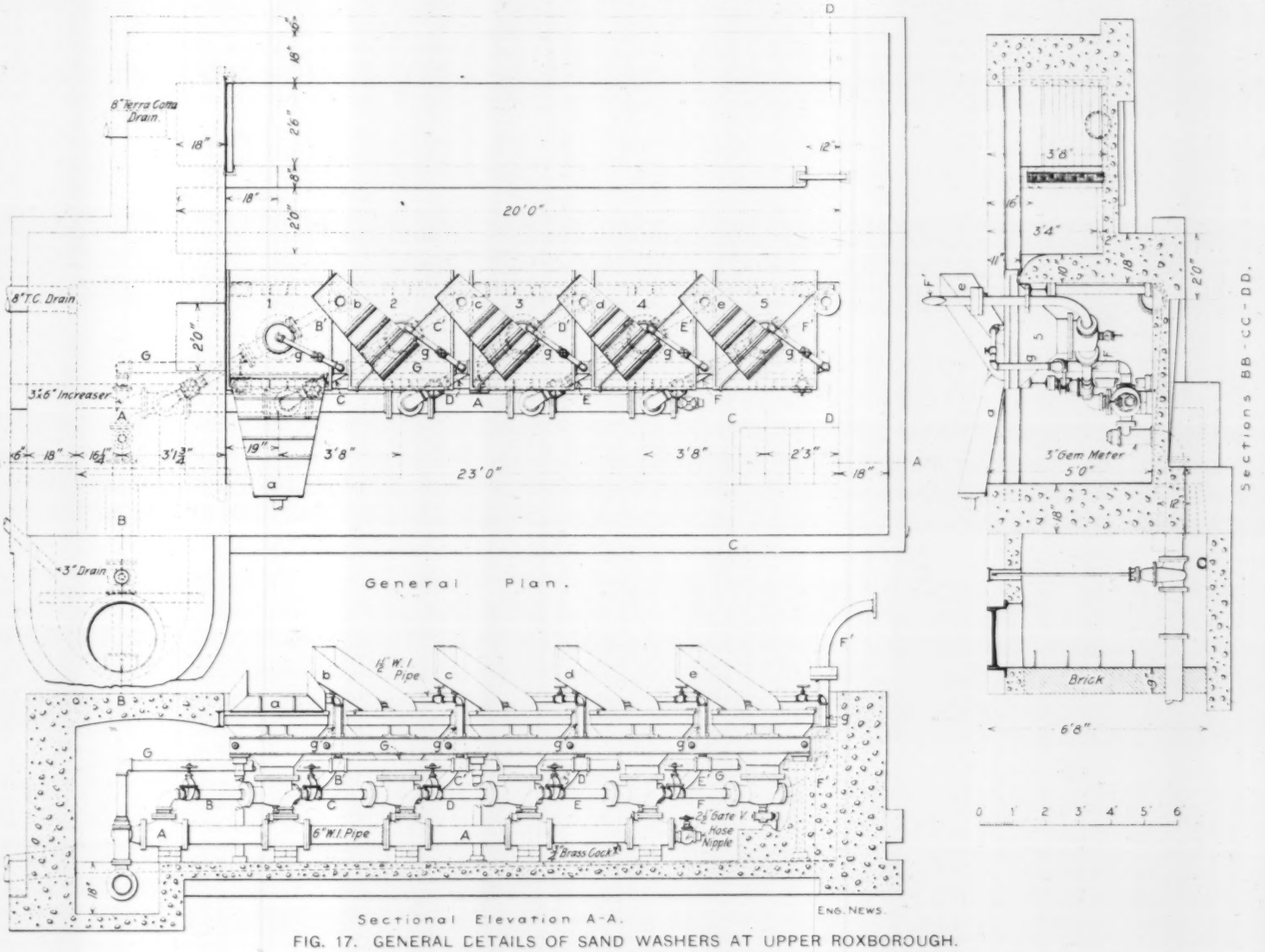


FIG. 17. GENERAL DETAILS OF SAND WASHERS AT UPPER ROXBOROUGH.

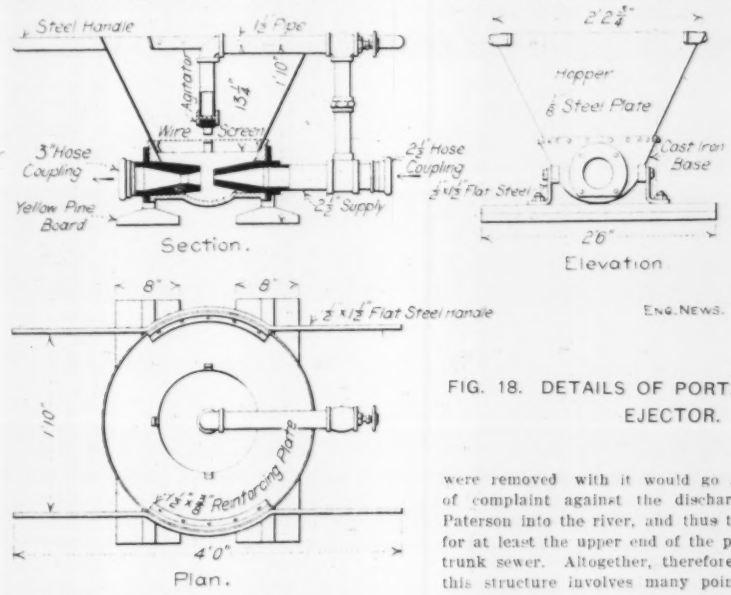
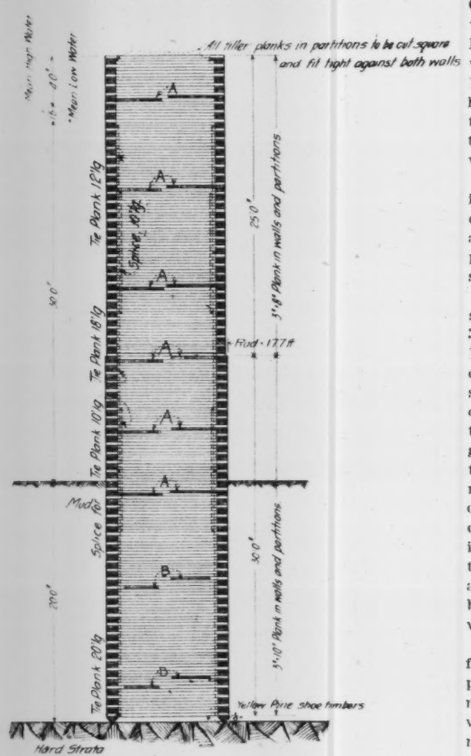


FIG. 18. DETAILS OF PORTABLE SAND EJECTOR.

PROPOSED COFFERDAM FOR RAISING THE BATTLESHIP "MAINE."

The U. S. Battleship "Maine" Salvage Co. has recently been incorporated in the District of Columbia for the purpose of entirely removing from the harbor of Havana the battleship which was destroyed on Feb. 15, 1898. The United States Government having relinquished all claims to the battleship, it becomes the property of the Cuban Government, which has made earnest efforts to secure its removal, especially because it forms a serious obstruction to the navigation of the harbor. The Cuban Government has finally entered into a contract with Mr. Joseph De Wyckoff, of Havana, under date of June 8, 1904, the work to be done under certain restrictions which are perfectly satisfactory to both parties. Mr. De Wyckoff is managing director of the United States Battleship "Maine" Salvage Co.

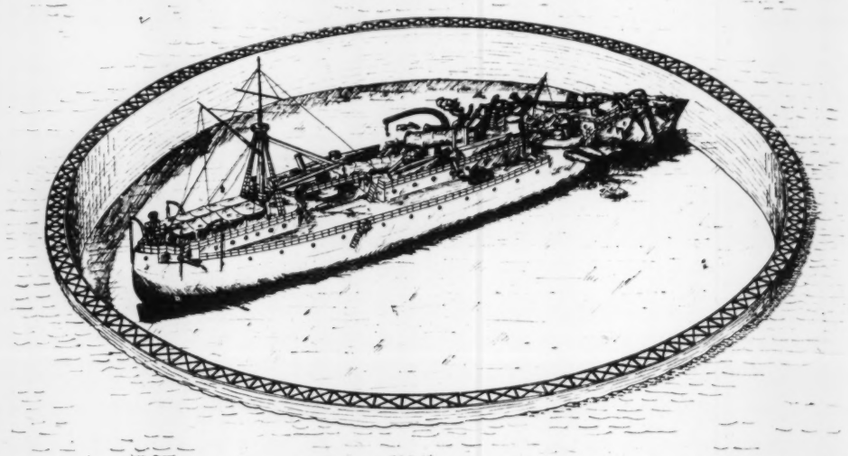
By recent action of the Cuban Government, the time for beginning the work has been extended to April 19, 1905, and the time for the completion to April 19th, 1906. As nearly as can be obtained from careful examinations of the wreck made with the aid of competent divers, about one-third of the battleship at the bow has been seriously injured, the other two-thirds remaining comparatively uninjured. It is the purpose of the company, first to remove the bodies of the sailors and their personal effects, and then to make the undertaking a financial success by the recovery of all valuable articles, such as arms, cannon, coal, machinery, etc., and the uninjured part of the battleship itself. It is also proposed to admit visitors to the wreck after the cofferdam is pumped out, charging an admission fee; and after the ship is floated, to exhibit it at the principal ports of the United States. It is also proposed to manufacture articles of brass, bronze and copper found upon the wreck into mementoes to be sold with certificates of American and Cuban officials as to their genuineness. Sufficient material of all kind will previously, however, be set aside for the erection of the contemplated memorial and placed at the disposal of the memorial committee. Photographers offer large sums for the exclusive rights to take views of the wreck from time to time as the water is being pumped out. The revenue which will be derived from these sources will be much more than sufficient to pay for the cost of building the necessary cofferdam and removing the wreck.



Section of Cofferdam on Line A A
Scale 1"=10'

Cross-Section of Cofferdam.

Should it be found possible to repair the damaged part of the vessel, it will be placed on the floating dock at Havana, and the battleship be completely repaired, when there, will be for sale to some government a complete battleship which originally cost the U. S. Government $5,000,000 to build and equip.



PERSPECTIVE SKETCH OF THE "MAINE" AS IT WILL LOOK AFTER THE SPACE AROUND IT IS ENCLOSED BY A COFFERDAM AND PUMPED OUT.

The battleship before the explosion had an extreme length of 324 ft., an extreme breadth of 57 ft., a draft of 21½ ft., and a displacement of 6,650 tons. The machinery cost $735,000. She was protected for 180 ft. amidships with 12-in. Harveyized armor worth $500 a ton. The turrets were of steel 8 ins. thick, and the barbettes were 12 ins. thick. It is believed that the steel and iron have not been materially corroded by the action of the water owing to the protection afforded by a thin marine growth upon all surfaces. The actual work in Havana harbor will be begun very soon.

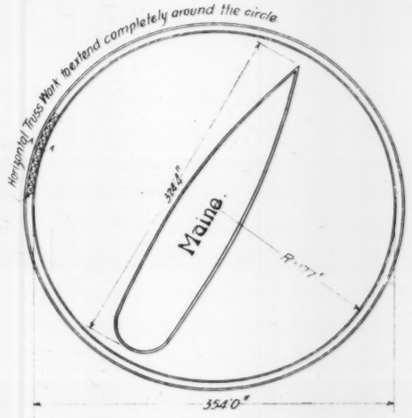
On account of the many difficulties in constructing a cofferdam by any of the customary methods, plans for a special construction peculiarly adapted to the requirements of the case have been prepared by the consulting engineers, a full description of which follows:

The cofferdam will be truly circular in form, as shown by the plan with an inside diameter of 354 ft. in the clear, thus providing a clearance of 15 feet at each end of the battleship. The cofferdam will consist of two concentric timber walls spaced 8 ft. apart in the clear, each wall being composed of 3-in. planks dressed to a uniform thickness, laid flat and thoroughly spiked together. The walls are to be tied together at intervals of between nine and ten feet by solid radial partitions also composed of 3-in. planks dressed to a uniform thickness, laid flat and thoroughly spiked. All partition planks contained, in every third horizontal layer are to extend through both circular walls to which walls they are to be spiked; all other partition planks are to be cut true to a uniform tight fit against both walls.

The principal stresses in the walls are circumferential, producing compression upon the wall planks in the direction of the grain. The external pressure will be distributed between the two walls by the partitions. In order that the external pressure may be distributed as evenly as possible upon the two walls with a minimum stress in the partition planks, the upper part of the inner wall will be pierced with holes and the lower part will be made tight so that when the cofferdam is pumped out the water will stand between the two walls at a point about 15 ft. below the surface of the water in the harbor.

In order to transmit the circumferential stresses between the adjoining planks in the same horizontal layer and at the same time secure tight joints against leakage, all such joints are to be cut true with a saw and laid tight for the full section of the plank. The joints in each third layer between the ends of the wall planks and the sides of the partition planks are also to be cut true and laid tight. In order that all horizontal joints may be tight, all planks used are to be dressed to uniform thickness; the edges will not be dressed. As an additional precaution against leakage between the faces of the wall planks, a small amount of heated coal tar pitch mixed with oil in such proportions as to render it firm but plastic when cold, will be poured along the center of each plank in place immediately before the following plank is laid and spiked thereto. Any leaks which may develop in spite of the precautions above mentioned are to be stopped by well-known methods, such as calking, by throwing suitable materials in the water outside of the dam so that these materials will be drawn into the crevices by the current, etc.; fine materials thrown into the water are well known to be efficient for stopping small leaks.

In order to make the dam tight at the bottom, careful soundings to the hard stratum are to be taken before the work on the crib is begun, so that if it becomes necessary to sink the crib as far as the hard stratum, its bottom edge will fit closely thereto. The flow of the water beneath the edge will be stopped by sinking a sufficient number of bags filled with sand and clay around the outside of the cofferdam, using a water jet it necessary. Interior puddle, which is very often used between the walls of cofferdams to prevent leakage and give necessary stability to the dam as a whole, will not be used in this instance because, owing to the peculiar form of construction, the interior puddle would add nothing to the stability and the tightness of the dam will be otherwise secured; the puddle, moreover, causes

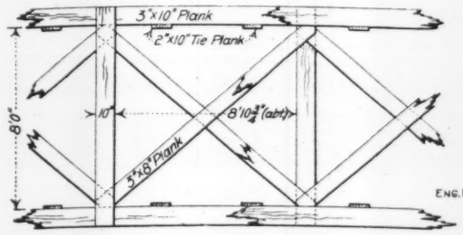


General Plan of Cofferdam for Raising Battleship "Maine."

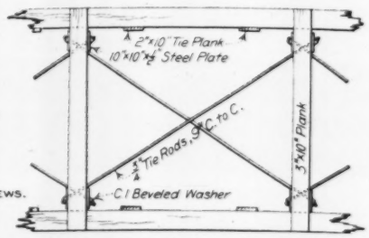
undesirable tensile stress in the radial partitions, and it would be removed only at a great expense on account of the interior bracing between the walls.

Should the borings on the site of the crib disclose considerable irregularities, Wakefield sheet piling of 2-in. plank in three thicknesses will be driven at these points to prevent the ingress of water, or the walls of the crib will be built to fit the irregularities.

The wreck is located within the harbor of Havana; the cofferdam will therefore never be subjected to the destructive action of the waves. In order, however, to stiffen the dam against any variations in pressure that may simultaneously exist at any given elevation between different points in the circumference and in order to give greater resistance to shocks caused by floating bodies or the impact of dredges or supply boats, etc., eight systems of horizontal truss work are provided, each one of which extends entirely round the circle. The compression members of this truss work are formed by the radial partitions. The diagonal members of the upper systems consist of 3 × 8-in. planks interlocking with the partitions; whereas, the diagonals of the lower systems which will have to sink through the soft material overlying the hard stratum will consist of ¾-in. iron rods so as to form no obstruction to the sinking of the dam. The various horizontal courses of plank are thoroughly tied together not only by spikes which will be driven slantingly, but by 2 × 10-in. vertical tie planks, four of which will be used in each of the 118 compartments formed by the radial partitions.



Sectional Plan of Cofferdam Showing Cross-Bracing A and Partitions.



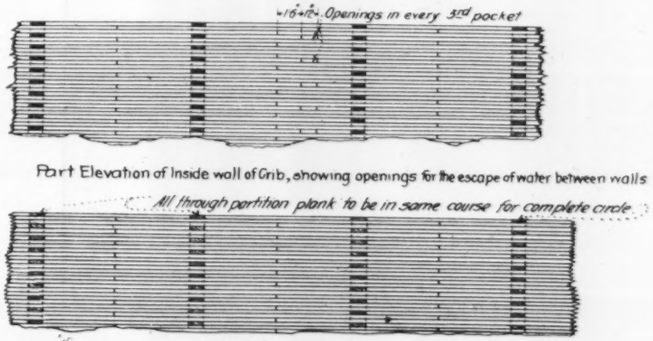
Sectional Plan of Cofferdam Showing Cross-Bracing B and Partitions.

In order to secure a truly circular form, the lower courses of the cofferdam will be temporarily secured to guide piles which will be secured against lateral displacement by temporary timber struts and ties which will extend from the guide piles to the wreck.

By the terms of the contract with the Cuban Government, the wreck and the cofferdam are to be finally entirely removed from the harbor of Havana. The customary method of sinking cribs by depositing ballast within pockets having timber bottoms, will, therefore, not be used on account of the difficulty of removing the ballast from the pockets. The cofferdam is, therefore, to be sunk with ballast consisting of rails or similar material resting upon the top of the walls, or of any suitable material which can be more readily obtained and carried upon timber floors resting upon the top of the dam. It will, therefore, probably be advisable to construct the crib to its full height before adding any ballast in order to avoid continually shifting the ballast during the progress of the work. All timber to be used will be long-leaf yellow pine or Cuban pine. The depth to which the completed cofferdam will sink before ballast is added, will depend upon the specific gravity of the timber, which is subject to slight variation. The lower edge will, however, be at about the top of the soft material. After the crib has been sunk a reasonable distance with the aid of ballast, pumping will be begun, any flow thus started under the bottom of the dam will soften or wash away the underlying material, facilitating the sinking of the crib until a suitably hard material is reached. Something over 2,000 tons of ballast will probably be required.

When the time comes for removing the cofferdam, all ballast will be removed. The top course of the plank will be taken off sufficiently to permit the dam to fill with water, and, if necessary, the materials around the outside of the dam will be dredged away until the dam is sufficiently loosened to float, after which it will be taken apart, course by course.

It is expected that the cofferdam will have to be pumped out to a depth of 30 ft. or more. The walls of the cofferdam will, under the external pressure, act as an arch subjected to uniform loads. Straight planks will, of course, be used. They will, however, be systematically overlapped and thoroughly spiked together in such a way as to entirely eliminate the bending stresses which would exist if the dam were built in a polygonal form. The principal stress is, therefore, that of compression in the direction of the grain. The weight of 1 cu. ft. of sea water being taken at 64.3 lbs., the maximum external pressure at that part of the dam when subjected to a head of 30 ft. is 1,929 lbs. per sq. ft. It will be remembered that every third layer of plank contains the ends of the partition tie-plank which receives the circumferential pressure from the ends of the wall planks. The ends of the partition plank can, it is evident, be much over-strained without in any way endangering the strength of the cofferdam as a whole. The assistance of these planks will, of course, add very materially to the strength of the dam. The strength will not be as great as would be the case if the stresses were at all points acting in the direction of the grain. If the strength of every third course be neglected, the compressive stress upon the timber would be 2,190 lbs. per sq. in. Taking the third course into account, the actual maximum compressive stress may be considered to be 1,600 lbs. per sq. in. This stress exists only in the lower portion of the dam and, passing upward, decreases constantly until it becomes zero at the surface of the water. The calculation given above ignores any benefit which may come to the lower part of the dam by the resistance of the upper part. The walls of the cofferdam are to be considered as short columns with fixed ends. Tests made at the Watertown Arsenal show that the ultimate strength of short columns of partially seasoned yellow pine is nearly 5,000 lbs. per sq. in. In many cases 1,000 lbs. per sq. in. would be as large a unit stress as should be permitted. In the present instance, however, it is to be observed that the work is of a temporary nature and therefore not subjected to any material deterioration. Furthermore, the stresses are caused by gradually applied loads and will not be increased by impact. A stress of even 2,000 lbs. per sq. in. would therefore be permissible.


4"x6"x4". Openings in every 3rd pocket
Part Elevation of Inside wall of Crib, showing openings for the escape of water between walls
All through partition plank to be in same course for complete circle
Part Outside Elevation of Crib showing how joints are to be broken.

ELEVATIONS OF CRIB WALLS.

If upon further investigation it is found that it will probably be necessary to pump out the cofferdam to a greater depth than 30 ft., its strength will be properly increased, and due allowance will be made for the fact that the mud overlying the hard stratum is in a semi-liquid condition.

To prevent injury by the limnoria and teredo, the upper part of the cofferdam from just below mud line to surface of water will be well protected before sinking with "carbolineum avenarius," or some other equally effective coating.

In reference to the design of this cofferdam it is interesting to note that a similar construction was used in the building of the pivot pier of the Charlestown, Mass., bridge, as shown by plate 41 of the Fourth Annual Report of the Boston Transit Commission. In the latter case a single wall was used and the diameter was 75 ft. It is stated by Mr. William Jackson, City Engineer of Boston, that the construction was very satisfactory and that no difficulties were experienced in sinking or building it.

The detail plans have been made by Mr. Wm. R. Davis, of Albany, under the supervision of Mr. E. L. Corthell and Mr. Edward A. Bond, to whom we are indebted for the plans and description of the proposed work.

Capt. Alex. H. Weber, Secretary of the U. S. River and Harbor Board of Washington, has been engaged as the Constructing Engineer to have charge of the work at Havana.

NOTES ON THE COMPUTATION OF STREAM GAGINGS.*

By O. V. P. Stout.†

THE HARLACHER METHOD OF COMPUTING DISCHARGE.—Occasion will be taken to present, for comparison with the methods usually employed in the computation of stream gagings, a method which is believed to be entitled to consideration by hydrographers. It has been called the Harlacher method, and consists, theoretically, in determining an area which is proportional to the rate of discharge of the stream at the gaging section. It will be set forth in connection with an example illustrative of its application.

Columns 1, 2 and 3 in the table on p. 522 are taken directly from the field notes. In Fig. 1 the straight horizontal line AB represents, to scale, the water surface at the gaging section. Points on the depth and velocity curves are located by scaling depths and velocities, respectively, as ordinates from the straight line. The ordinate from the straight line to the discharge curve is, to scale, at any point, the product of the observed depth and velocity at that point. These products are noted in Columns 4 and 5 of the table. It is evident that the area of the figure bounded by the straight line and the discharge curve is, to scale, the rate of discharge of the stream. This area may be measured by planimeter, or it may be computed by any one of the approved methods of calculating the areas of irregular figures. It has been the custom, in practice, to compute the area by Simpson's one-third and three-eighths rules, and it is rarely that the figure has been drawn or the planimeter used.

Recurring to the table, the process of computation will be explained. Two columns for products of velocity by depth have been provided in order to facilitate the separation of those products which, as ordinates to the discharge curve, are to be multiplied by different factors. Those which are taken once or twice are placed in Column 4. Those which are multiplied by 3 or 4 are written in Column 5. Using Simpson's one-third rule, the discharge passing the first 6 ft. in width of the stream is

$$4 \times 0.544 + 1.738 = 3.914.$$

This partial discharge is noted in Column 6. The discharge through that part of the width of the stream from 6 to 54 ft. from the initial point is

$$2\ (1.738 + 2 \times 2.686 + 1.738 + 1.592 + 4 \times 2.488 + 2.662 + 2.070 + 1.410 + 1.261) = 99.102.$$

*A paper prepared for the Section of Engineering and Mechanics, Twelfth National Irrigation Congress, El Paso, Tex., Nov. 15 to 18, 1904.

†Irrigation Engineer, Nebraska Agricultural Experiment Station, Lincoln, Neb.

From 54 ft. to 72 ft., Simpson's three-eighths rule is used, giving

$$\tfrac{3}{8} \times 6\ (1.261 + 3 \times 1.212 + 1.225 + 1.482) = 22.622.$$

Finally, from 72 to 77 ft., the discharge is

$$\tfrac{1}{3} \times 2\tfrac{1}{2}\ (1.482 + 4 \times 1.017) = 4.625$$

Incidentally it may be noted that the Harlacher method lends itself to a convenient expedient for allowing for variable angle of current at a gaging section. The reduction is accomplished by multiplying each measured depth by the cosine of the angle by which the current at that point deviates from right angled approach to the gaging section.

DISCHARGE DETERMINED WITHOUT EXTENDED COMPUTATION.—The rating equation of current meters is usually of the form $v = ar + b$ where v = the velocity in feet per second, r = record in one second, and a and b are constants.

Measure depths and velocities at the same points at equal intervals across stream. Let i be one of these equal intervals. At each observation of velocity let the meter run during a period equal to k seconds for each foot of depth d at any point. Then the record for a single observation is $kdr = \frac{k}{a} vd - \frac{kb}{a} d$. By the trapezoidal rule for computing areas, Harlacher's discharge curve would give the total discharge of the stream $q = i \Sigma v1$. The area of the cross-section is $A = i \Sigma d$.

Then the total record for a gaging is

$$R = k \Sigma dr = \frac{k}{a} \Sigma vd - \frac{kb}{a} \Sigma d = \frac{k}{ai} q - \frac{kb}{ai} A.$$

Solving for q, the desired quantity, we obtain an equation of the form $q = mR + nA$, where m and n are constants, $(m = \frac{ai}{k}, n = b.)$

Therefore, immediately upon the completion of a gaging, R may be obtained by adding the meter records, A by adding all depths and multiplying the sum by i. Then these values of R and A may be substituted in

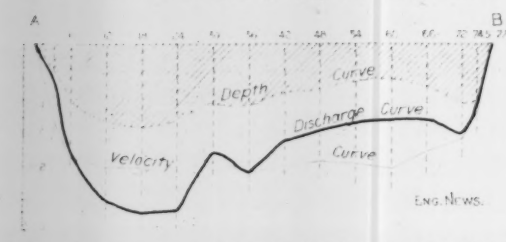


Fig. 1. Diagram Illustrating Harlacher Method of Computing Stream Discharge.

$q = mR + nA$, and the discharge of the stream obtained at once.

DISCHARGE DETERMINED ENTIRELY WITHOUT COMPUTATION.—In Fig. 2 are shown the elements of an apparatus for tracing Harlacher's discharge curve.

The bar C D moves from left to right, being kept perpendicular to the base line, with the fixed point A on the base line. C D is slotted so that the tracing points B, C and D may move along it.

A E is a bar fixed rigidly to C D at A, the angle D A E being 45°. It is slotted so that a lug fixed to E F and through which D E passes may move along A E.

A F is a bar pivoted at A. It is slotted so that the points G and F may move along it.

B G is of unit length. The lug and block at B are so constructed that A B G is always a right angle, although B moves along A C. A pivoted lug at G works in the slot in A F.

C F is a bar having at C a block and lug so constructed that B C F is always a right angle, although the lug at C is free to move in the slot in A C. C F passes at F through a block which carries a pivoted lug which slides in the slot in A F.

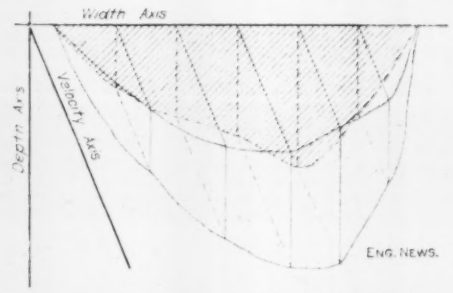


Fig. 2. Elements of an Apparatus for Tracing Harlacher's Stream Discharge Curve.

E F is a bar which is always parallel to C D but at varying distance from it, these conditions being effected by the construction and connections of the block and lug at E. E F passes through the block at F.

Now, if B and D are made to trace the velocity and depth curves, respectively, then will C trace the discharge curve.

Note that the depth = A D = D E = C F, or depth C F.

Also, A B : A C = B G : C F, or velocity : A C = 1 : depth.

Whence A C = velocity x depth = ordinate to discharge curve.

If an instrument constructed on this principle be used to trace the discharge curve, the depth and velocity curves having previously been plotted from the field notes, a planimeter can be run around the discharge curve and along the base line, thus giving the discharge of the stream without computation.

A CONCEPTION OF STREAM DISCHARGE AS A VOLUME.—Having given the cross-section of a stream at a point where a measurement of discharge has been made, imagine each elementary vertical strip of said section to be advanced down-stream through a distance equal to the mean velocity of the water through that vertical strip. The cubic content of the solid thereby generated is equal to the volume of water which passes through the gaging section in one unit of time. Fig. 3 is a representation of such a solid.

Any method of computation which will determine the volume of the solid may be used in calculating the discharge of the stream. Any method which is not legitimately applicable to the determination of the volume of the solid should not be used in calculating the discharge of the stream.

Note that if the depth and velocity may be considered as varying uniformly between the points at which measurements have been made, the solid becomes a succession of prismoids, and the prismoidal formula will apply with precision. The volume of the prismoid may be written

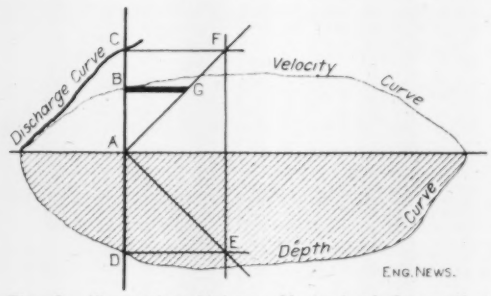


Fig. 3. Illustrating Volume Method of Computing Stream Discharge

$$V = \frac{i}{6}\left[v'd' + 4\left(\frac{v'+v''}{2}\right)\left(\frac{d'+d''}{2}\right) + v''d''\right] =$$

$$\frac{i}{6}\left[2v'd' + v'd'' + v''d' + 2v''d''\right] =$$

$$\frac{i}{3}\left[v'\left(d' + \frac{d''}{2}\right) + v''\left(d'' + \frac{d'}{2}\right)\right].$$

In the foregoing equations i = the distance between successive points of measurement of depth, and velocity = the length of the prismoid considered.

The final form of equation gives rise to the following rule for computation:

Increase the depth at each end of the prismoid by one-half of the depth at the other end. Multiply each of those increased depths by the corresponding velocity, add together the resulting products, and multiply the sum by one-third of the length of the prismoid. The result is the volume of the prismoid.

The method of averaging end areas may be examined in this connection. According to this method

$$V = \frac{i}{2}(v'd' + v''d'')$$

If from this volume that found by the prismoidal formula be substracted the difference is

$$C = \frac{i}{6}(v'd' - v'd'' - v''d' + v''d'') = \frac{i}{6}(v' - v'')(d' - d'')$$

This difference or correction reduces to zero when either $v' = v''$ or $d' = d''$, and becomes insignificant when either of these relations is approached.

Gaging of Mitchell Canal at Headgate, near Wyoming Nebraska Line, 5 p. m., Sept. 1, 1903.

(1) Distance from initial point.	(2) Depth.	(3) Velocity.		(4) Product, velocity by depth.	(5) Product, velocity by depth.	(6) Discharge.
0	0.00	....	×	0.000	.....	.....
3	0.45	1.21	—	.....	0.544	.....
6	0.95	1.83	×	1.738	.....	3.914
12	1.25	1.99	—	.....	2.488	.....
18	1.35	1.99		2.686	.....	.....
24	1.25	2.13	—	.....	2.662	.....
30	0.95	1.83		1.738	.....	.....
36	1.00	2.07	—	.....	2.070	.....
42	0.80	1.99		1.592	.....	.....
48	0.75	1.88	—	.....	1.410	.....
54	0.65	1.94	×	1.261	.....	99.102
60	0.60	2.02	—	.....	1.212	.....
66	0.70	1.75	—	.....	1.225	.....
72	0.95	1.56	×	1.482	.....	22.622
74½	0.90	1.13	—	.....	1.017	.....
77	0.00	....	×	0.000	.....	4.625
				Total	.....	130.263
				Say.....	.....	130.3

The marks which appear on the line between Columns 3 and 4 are written in previous to computation, and have the following significance:

× Indicates that the end of a "run" of computation has been reached, and that, except on the first line, a partial discharge is to be noted on that line.

— Indicates that the product of velocity by depth on that line is to be written in Column 5.

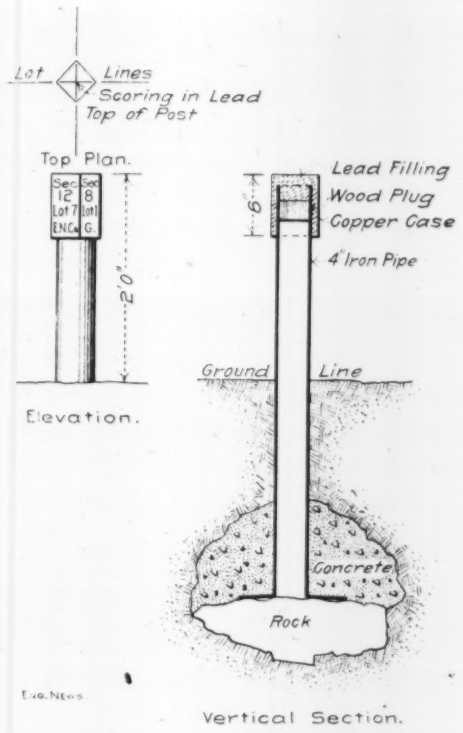
The horizontal lines across Columns 4 and 5 have been drawn to facilitate the separation of quantities in those columns into groups which are to be added and multiplied by a single number.

A LIGHT WEIGHT METAL LAND BOUNDARY MONUMENT.

By F. M. Goodhue.

The accompanying sketches show a post to mark land corners, designed for situations where it is inconvenient, by reason of cost, distance, or lack of transportation facilities, to use a standard stone monument, or where the rural "stake and stones," for obvious reasons, is not desired.

Over the top of an iron pipe is slipped a square copper sleeve, made preferably of sheet copper 1-16 or 3-32-in. thick. Its seam should be riveted. Into this sleeve is poured melted lead, prevented from running below the copper by any readily ex-



A Light-Weight Metal Land Boundary Monument.

temporized collar about the pipe, and from wasting inside the pipe by a wooden plug an inch or so below the top. Holes drilled through the upper end of the pipe provide a lock for the lead. The foot of the pipe is split and spread, as shown. In setting the post it can be placed upon a foot stone and surrounded by concrete. The concrete will usually be good enough if made from the material excavated from the hole, and tamped about the monument. Two feet is a convenient height for the post to project from the ground so an instrument can be centered over it.

The thin copper backed by the lead, takes any mark desired if struck with a somewhat dulled cold chisel, which had best be narrow to turn letters and figures containing curves. The top surface being of lead takes any scoring, indicating the intersection and direction of the lot lines.

This monument complete weighs 20 to 25 lbs. I have set it in the midst of the Adirondack woods and find it combines the portability and ease of marking of a wooden stake with almost the permanence of stone.

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As we briefly noted in our last issue, the eight-hour law of the State of New York has been declared unconstitutional by the Court of Appeals. This is the fourth decision of the Court of Appeals against this law, which was enacted in 1897. As both contractors and engineers in the State will be particularly interested in the recent decision we shall briefly summarize the previous decisions as well as this last decision which seems to utterly wipe out the eight-hour law.

The first decision against the law declared unconstitutional that section which requires contractors for the State or for municipal work to pay "the prevailing rate of wages." The second decision lopped off that part making it compulsory for contractors to use stone cut in New York State. The third decision was against that section of the law which made it a crime to work employees more than eight hours. Finally, this fourth and last decision nullifies the eight-hour provision entirely, as indicated by the following press reports:

ALBANY, Nov. 29.—By a decision to-day in the action of the People ex. rel. Cossey, appellant, vs. Controller Grout of New York, the Court of Appeals declared unconstitutional Chapter 415 of the Laws of 1897, (the labor law,) which prohibits a contractor from employing his men more than eight hours a day on city, county or State work.

Since its enactment in 1897 this statute has been almost continually before the courts. Other phases have been passed upon, but this is the first time that the Court of Appeals has expressed its views flatly on the eight-hour provision.

The action was brought by Harry Cossey to compel payment by the City of New York of $28,215 for six scows manufactured for the Street Cleaning Department. Payment was refused on the ground that he had violated the terms of his contract in employing his men over eight hours a day. Cossey did not deny this, but contended that the law was unconstitutional. The Court of Appeals reverses the lower courts and grants the appellant's application, though not entirely on the arguments advanced by his counsel.

With Judge Haight alone dissenting, the court arrives at this conclusion, but by different routes. Judges O'Brien, Martin and Vann hold that the law is unconstitutional in that it deprives an individual of property without due process of law. Chief Judge Cullen, with Judge Werner concurring, bases his opinion as to the law's unconstitutionality on the result in the Rogers case, making their decision one of precedent.

Chief Justice Cullen takes the ground that the principle involved is precisely similar to that in the action of the People ex. rel. Rogers vs. Coler. The latter was the earliest case that arose under the labor law, and in deciding the courts held that the statute was unconstitutional in so far as it involved the "prevailing rate of wages." Judge Cullen says, comparing the two cases:

"This difference in circumstances would not justify a distinction in principle, and therefore the decision in the Rogers case must control the disposition of the present case unless the Rogers case has been overthrown by subsequent cases in this court or in the Supreme Court of the United States."

The rest of his opinion is devoted to a discussion of the other cases under the labor law, from which he decides that the conclusion in the Rogers case stands and applies in the action under discussion.

In his conclusion the Chief Judge says:

"I fear that the many outrages of labor organizations or of some of their members have not only excited just indignation, but at times have frightened courts into plain legal inconsistencies and into the enunciation of doctrines which, if asserted in litigations arising under any other subject than labor legislation, would meet scant courtesy or consideration. . . .

"The decision about to be made can therefore stand only on one ground, the unconstitutional interference of the Legislature with the right of the municipality. That proposition having been explicitly decided in the Rogers case, I feel it my duty to follow it, regardless of my own opinion on the question."

Judge O'Brien says:

"One of the grounds upon which the Rogers case rests is that the statute there considered and now before us deprived the contractor of his property without due process of law, and the learned Chief Judge, as I understand the opinion, asserts that this ground has been entirely swept away by the case of Atkins vs. Kansas, in which the United States Supreme Court affirmed the conviction of a contractor for violating the eight-hour law of that State.

"I do not concur in that view. In my opinion, the Kansas case does not decide or sweep away what we held in the Rogers case and should hold in this case, namely, that the statute in question violates the Constitution of the State, in that it deprives the relator in this case, as it did in the Rogers case, of his property without due process of law."

In his dissenting opinion Judge Haight holds that the constitutionality of the law can be sustained by the fact that it is a police regulation, in the interest of public health and morality.

The effect of this decision will be far reaching, but perhaps the most important effect will be upon the prices that will be bid upon the work for the $100,000,000 Barge Canal, part of which is now advertised in our columns. Since the cost of the greater part of this work depends upon the rate of wages, and since an 8-hour day adds 25% to the cost of work done on a 10-hour basis, it is evident that bidding prices will be greatly affected by this decision.

However, if we mistake not, the State itself, and for that matter any municipality in the State, is still at liberty to insert an eight-hour provision in its contracts, although it can not be forced to do so. It is not at all likely that this will be done, for taxpayers will resent any attempt to saddle them with a cost greater than is necessary for a given piece of public work.

There remains the uncertainty as to strikes, for labor unions will unquestionably resist any attempt made to increase the hours of labor. In the larger cities they will doubtless be successful, for a time at least; but in the smaller cities and on canal and roadwork outside of the cities it is probable that the ten-hour day will prevail at least for some years to come.

Since the above was put in type we have received specifications for some of the Barge Canal work, and find that the contract as there printed practically embodies the conditions of the eight-hour law. The contract was drawn before the recent decision of the Court of Appeals, but now that the eight-hour law has been declared unconstitutional it devolves upon the State officials to make some public announcement to settle the doubt that will exist in the minds of many contractors who contemplate bidding. So long as State contracts continue to embody the paragraphs of the eight-hour law, we are inclined to believe that the law virtually remains in full force, so far as the State and the contractors for the State are concerned. Morally, however, it may be questioned whether the State has any right to require the employees of contractors to work 20 fewer hours than the same employees would work for railway companies, or for private individuals on precisely the same character of work. In a word, the taxpayers for public work should not be asked to pay higher rates for work than they would have to pay as individuals. But aside from any question of ethics or politics, contractors should be given public notice as to whether or not the State proposes to keep the eight-hour law alive on State work; otherwise they cannot bid intelligently on the pending canal contracts.

We regret to record another reported case of discrimination in Canada against engineers from the United States. The City Council of Halifax, Nova Scotia, engaged a well-known Boston engineer, Mr. F. A. Barbour, of the engineering firm of Snow & Barbour, to report on the improvement of the city's water supply system. The ordinance making the engagement, however, was vetoed by the Mayor on the following grounds:

First—Because Mr. Barbour is a resident of the United States, and at present residing in Boston.

Second—Because I am of opinion that we have engineers in our own country, and within the Dominion of Canada equally competent.

Third—Because no such engagement could be made with any resident of this country to do work in the United States.

Passing for the moment, the first two of the Mayor's reasons, we desire to make reply to his third reason:

There is no prejudice against the employment of Canadian engineers in the United States. On the contrary, a large number of the prominent members of the engineering profession in the United States are natives of Canada. It may be said that this is not the same as the employment of a non-resident consulting engineer on a specific piece of engineering work; but let us examine this argument closely. The Mayor objects to the employment of a Massachusetts engineer because, forsooth, Massachusetts cities do not consult Nova Scotia engineers. On exactly the same ground the Mayor of a town in Maine or Vermont might object to the employment of a Massachusetts engineer, because Massachusetts cities do not send to Maine or Vermont for engineering advice any more than to Nova Scotia. And we do not believe that there is any more prejudice in Massachusetts against Nova Scotia engineers, because they are Canadians, than there is against Vermont engineers. The simple fact is that a city in the United States with a tough engineering problem on its hands goes where it can find competent engineering advice; and consulting engineers with ability and experience and reputation are to be found almost wholly in the larger cities.

To make the Mayor's case still weaker, it transpires from a statement in the Halifax "Herald" that Mr. Barbour is actually a British subject (we infer of Canadian birth) that he went to Boston to obtain professional experience, and resides there as a matter of business. This should be proof positive that the prejudice which the Mayor imagines to exist in the United States against Canadian engineers has no foundation in fact.

There is another inherent fallacy in the Mayor's position, and that is the idea that the work ought to go to the man who needs it most, whereas the true standard to measure by is to determine who can best perform it. The Mayor is concerned lest the city should pay fees to some non-resident; and this same vicious principle is at the bottom of we know not how vast an amount of loss and waste and mismanagement in both private enterprises and public. There is nothing which plays ducks and drakes with the taxpayers' money and the citizens' welfare faster than the policy of placing contracts and making appointment with an eye to the benefit of the contractors and the appointees rather than the public interests. What difference does it make to the Halifax taxpayers whether the engineer who remodels their water supply is a subject of King Edward or a citizen of the United States; whether his usual residence is in Hawaii or Halifax? What the residents of a city want is the engineer who has the ability to produce the best results with the smallest expenditure.

Perhaps the Mayor's opinion may be correct that the city can obtain a resident Canadian en-

gineer as competent as Mr. Barbour; but it is certainly the rule that the men of largest experience in handling the large problems of engineering are found in the larger cities, since it is only there that they can find sufficient business to enable them to gain the experience that makes them competent.

We strongly deprecate such occurrences as this at Halifax since they tend to stimulate international prejudice and disturb the harmony and good fellowship between the branches of the profession resident on either side of the border.

It is to offset this influence and contradict the idea that prejudice against the employment of Canadian engineers, because they are Canadians exists on this side of the border that this note is penned.

CEMENT AND OTHER PIPE JOINTS IN RELATION TO ELECTROLYSIS.

Is there any practicable, equitable and certain means of preventing the electrolysis of gas and water mains short of using insulated returns for conveying electric trolley currents back to the power house? We have purposely made the question broad because the electrolysis question cannot fairly be considered from a single viewpoint. We have always held and we still maintain that the burden of electrolysis prevention rests with the producer of the current. But assuming for the moment that expediency demands preventive measures on the part of owners of water and gas mains, are there any sure and at the same time practicable measures which they can adopt to protect their property from destruction? We shall not attempt a complete answer to our opening question. It has been asked chiefly for the purpose of arousing criticism of the forms of joints mentioned below; criticism of the joints both as related to electrolysis and as bearing upon the broader questions of water and gas main construction and maintenance. These questions have been raised by the following letter from a well-known engineer located on the Pacific Coast:

CEMENT JOINTS AS A CURE FOR ELECTROLYSIS.—OTHER USES OF CEMENT.

Sir: I think Mr. Wm. Mulholland, Engineer and Superintendent of the Los Angeles City Water-Works, should be given credit for the discovery that a certain and positive cure for electrolysis in water pipes is to lay them with cement joints, instead of with lead. Each joint is thus so completely and perfectly insulated as to stop the passage of stray currents.

A few years ago the water mains of this city were seriously crippled by electrolysis, and although the electric railway companies took extraordinary precautions to prevent the escape of their currents into the water pipes, they were unable to stop the wholesale destruction of pipe until Mr. Mulholland began experimenting with cement joints. He has proven by most rigid tests with delicate ammeters that the remedy is effectual, and has adopted cement as a substitute for lead in cast iron pipe-laying universally through the city, under any pressure up to the maximum of 120 lbs. or more, wherever he can hold the pipe out of commission for three days or over.

He mixes the Portland cement neat, rather dry, merely moist enough to ball up in the hand, rams it carefully in place on to a packing of yarn, as with lead joints, and keeps it moist until put into service. He usually turns on full pressure after three days. Recently in moving to conform to a changed street line, a line of 8-in. pipe, which had been laid with cement joints and in service for some years, he tried to see how much abuse the joints would stand. The line was separated into sections of four or five lengths each, and these were dragged by horses over rough ground, kinking and straining the joints severely. They were then connected up, and when the water pressure was turned on they were found to be tight except for a slight ooze and "spitting" or "sweating" which continued a few hours, after which the joints became entirely tight. Lead joints would not stand this sort of treatment as well as the cement appeared to do.

Apropos of the velocity which cement pipe will stand with clear water flowing through, Mr. Mulholland made a striking experiment with the nozzle of a Pelton water wheel some years ago. Wishing to reduce the size of his nozzle from 4-ins. to 2¾ ins., and having no spare cast iron nozzle of the proper diameter at hand, he placed a wooden core inside the large nozzle and around the core he molded an annular ring of cement ⅝-in. thick. After being placed in water for a few days after the cement had set, the nozzle was put in service, the water passing through the annular ring of cement with a velocity due to a head of 60 ft. It was kept in service 13 years, and when removed a few weeks since showed no sign of wear. Even the finger marks by which it was molded and finished smooth were visible.

A striking case of this character is reported at the Puyallup power house of the Puget Sound Power Co. (Eng. News, Sept. 29, 1904) by Mr. E. H. Warner, Principal Assistant Engineer. The spray from a stream under a jet velocity of 232 ft. per sec. has impinged for three months against the underside of concrete arches without producing visible wear. The concrete was ordinary 1:3:6, without plaster coat.

Mr. Mulholland has also successfully used cement as a gasket in fitting old parts of large pumps together. The object of the cement in this case was to save time and cost of planing down irregular surfaces. His experiences with cement seem worthy of record for the benefit of younger members of the profession and as a means of bringing out the observations of others in this line. I have seen no mention of this electrolysis cure in engineering journals, and am inclined to think it original.

Jas. D. Schuyler.

Los Angeles, Cal., Nov. 11, 1904.

So far as we are aware, cement joints have not been suggested by anyone else, much less put in use, as a preventive of electrolysis. Such joints have been used in several instances for water mains and quite extensively for many years past by gas companies, but in no case prior to the one reported by Mr. Schuyler, so far as we know, with the idea of abating electrolysis. We understand that cement joints for gas mains are growing in favor, and that whereas such joints were formerly restricted to small sizes of pipe they are now being satisfactorily used in Philadelphia for 30-in. mains.

At first thought it may seem that this use of cement joints for gas mains is in large part responsible for the fact that electrolysis seems to be damaging gas mains far less than water mains. In weighing the probabilities of the proposition, however, it should be remembered that the water in the mains and the relatively larger amount of dampness of the earth just without them add materially to the conductivity of water mains as compared with gas mains. The mileage of water mains and services in the United States is far in excess of the mileage of gas mains. Numerous small leaks in gas mains go unnoticed, and large leakages do not make themselves known at the surface as is often the case with breaks in water mains. The slight internal pressure on gas mains is not sufficient to burst the carbonaceous wall left by electrolytic corrosion, so gas pipes do not collapse except by external pressure. Nevertheless, a large amount of gas leakage does occur and doubtless not a little of it is due to electrolysis. The public hears little of electrolytic damage to gas mains, partly because the gas companies, for the reasons stated, do not themselves know just what is going on underground and partly because they do not tell all they do know. Moreover, many of the gas companies are so closely allied with the electric street railway interests either financially or for protecting corporate interests, that the gas companies often keep their troubles with electrolysis from the public, lest the municipalities make capital of those troubles in their fight against the electrolysis of water mains. Some gas companies, however, have taken precautions against electrolysis, one instance of which is cited below.

It may be interesting and possibly instructive to review some of the jointing methods previously suggested or used as a preventive of electrolysis.

On p. 288 of our issue of Nov. 3, 1898, we published a suggestion by Mr. Harold P. Brown to the effect that electrolysis of both gas and water mains might be prevented by inserting at intervals two or more lengths of wood pipe. In our issue of July 22, 1899 (p. 39), we printed a note on the use at St. John, N. B., of pine plugs in place of lead for joints on a 12-in. water main laid in 1851, a 24-in. main laid in 1857, and a second 24-in. main laid in 1898 or 1899. In the same issue (p. 40) we suggested that wood joints might serve as a preventive of electrolysis. The wood joints at St. John, for 24-in. pipe, cost only 70 cts., of which 13 cts. was the contract price of the wood staves and 57 cts. the cost of the day labor employed by the city.

Long before electrolysis was dreamed of, cement joint were used on a line of small cast iron pipe at Central Falls, R. I., and as early as 1892 the use of cement joints for water mains had been reduced to a scientific basis at Nottingham, England.

The use of cement joints at Central Falls, R. I., was brought out by an inquiry from Florida, published on p. 458 of our issue of May 5, 1892. At the time the inquiry was received, we knew of but one instance of the use of cement joints for water mains. That was on a pipe under light head supplying a factory, and it was reported that the joints gave much trouble from leakage. Following the inquiry and reply just mentioned, Mr. C. H. M. Blake, C. E., of Guadalajara, Mex., wrote us (Eng. News, June 23, 1892) that in 1880 while in charge of water-works at Central Falls, R. I., he found about 1,000 ft. of 6-in. cast iron pipe with cement joints in use. The pipe, on his advice, was incorporated in the new water-works. The pressure on the pipe, as Mr. Blake remembered it, was 100 lbs. He stated that no leaks were detected, but did not say what means were taken to find whether or not they existed.

Mr. Blake's letter was seen by Mr. W. P. Snow, of Auburndale, Mass., who referred us to the Pawtucket Steam & Gas Pipe Co. for details. Mr. J. E. Andrews, Secretary of that company, wrote us a letter (Eng. News, July 14, 1892) from which we take the following:

In 1869-70 the company named installed a fire service for the Central Falls fire district, consisting of 4 and 6-in. pipe and a pump. The joints consisted of a layer of tarred rope, well calked in a layer of Roman cement, then more tarred rope, well calked, and finally more of the cement to point up the joint. The gage on the fire pump frequently showed as high as 150 lbs. pressure. "In our recollection," Mr. Andrews states, "we never had a leaky joint." (Meaning, we suppose, one that showed at the surface.—Ed.) About 1880 a portion of the cement-jointed pipe was incorporated in a new water-works system, and at the date of Mr. Andrews' letter (1892) it was still in daily use, under 90 to 100 lbs. pressure. In 1890 a leak in this pipe was attributed to a failure of a joint, but on uncovering the pipe for 50 ft. every joint was found to be "perfectly sound." The leak was caused by a split in the body of the pipe. The bells in these pipes were 4 ins. deep. Mr. Andrews believed that a less depth than this would not give room for a sufficient body of cement.

One more letter was added to the chain started by our Florida inquirer. This was from Mr. L. T. G. Evans, Engineer of the municipal water-works of Nottingham, England, and was published on pp. 235-6 of our issue of Sept. 8, 1892. It was accompanied by a section and table of dimensions of "turned and bored socket water pipes, suitable for cement jointing," for 2 to 24-in. pipe. The spigots of this pipe are turned to a very slight taper, and the sockets bored to correspond. The socket extends a short distance beyond the taper fit portion, so as to form a recess, like that of the ordinary joint, on the outside of the joint. Just before laying this pipe the tallow which had been applied to the machined parts to prevent corrosion was wiped off and in its place neat liquid cement was applied. On being lowered to position the pipe was driven home with a wooden mallet, until no further movement could be detected by a foreman feeling the progress made at each blow. The annular recess outside the taper fit was then packed with cement. The machine work for these joints (in 1892) cost from $1.20 per ton of pipe for the small sizes to 85 cts. for the large diameters in excess of ordinary joints, but this was described as "exceedingly small compared with the great saving in lead, yarn, grip poles, labor, etc," required for lead joints. On examination old cement joints had invariably been found good, even in places where the concussion had been considerable. In colliery and mining districts and where there was considerable expansion and contraction due to varying water temperatures Mr. Evans thought cement joints would not be suitable.

As has been stated, cement joints are commonly used for gas mains. On May 7, 1903, we published an abstract of a paper by Mr. W. A. Larned on "High-Pressure Gas Distribution at Newton, Mass." Cement was used for joints there, but the main reliance for tightness seems to have been the Dresser joint and a clamp for other joints.

The Dresser joints are socket joints, packed with cement and sealed with a rubber ring held in place by bolted flanges. A rubber was also employed for the other clamped joints. This pipe line was 9,600 ft. long and 6 ins. in diameter. In one hour 18,200 cu. ft. of gas was forced through it, with an initial pressure of 10 lbs. and a final pressure of 9.28 lbs. Mr. Larned stated that the clamped cement joint would stand a pressure of 40 lbs.

An earlier notice of the use of the Dresser joint in a high-pressure gas main appeared on p. 513 of our issue of June 26, 1902, and was extracted from a paper by Mr. Edward J. Humiston of Chicago, on "Electrolysis of Underground Metals," read before the annual meeting of the Western Gas Association. For 13 miles a main of the North Shore Gas Co., of Waukegan, Ill., parallels a trolley line. Tests showed that about 25 per cent. of the current was returning to the power house through the mains. Rubber-packed Dresser joints were placed at intervals of 1,200 ft. It was believed that 90% of these joints completely broke the conductivity of the main, but this being deemed insufficient two breaks of 10 ft. were made by inserting insulating couplings with rubber packing.

The foregoing notes have been brought together for the convenience of our readers and in hopes of bringing out other accounts of practice, and not to lessen any credit due to Mr. Mulholland for adopting cement joints to prevent electrolysis. We think Mr. Mulholland deserves credit for making tight joints with cement, a thing which is seldom done in sewerage construction, and which is by no means always done in laying gas mains.

Electrolysis is so vital a question, and securing tight joints in water, gas and sewer pipes, regardless of electrolysis, is so important and difficult a matter that we trust Mr. Schuyler's California letter will bring out even more information on joint construction than did the letter from Florida which we published twelve years ago.

Obviously it would be impracticable and unjust for a water or gas works to be obliged to tear up old mains and rejoint them with cement or any other material. It does not seem to have been established by practice, at least by water-works practice, that a few insulating joints or lengths of non-conductive pipe would be efficient.

We fear water-works men in general will be slow to change, on new work, from lead to cement joints until more evidence of the reliability of the latter has accumulated, while as for old mains we do not suppose either Mr. Schuyler or Mr. Mulholland consider such a change probable, even if they think it desirable. As to new mains, certainly the positive statements by Mr. Schuyler regarding Mr. Mulholland's experience at Los Angeles indicate that the use of cement joints is worth a trial in other cities, provided that owners of water and gas mains are going to accept the burden of electrolysis prevention instead of placing it on the trolley companies, where it belongs.

We think tests of cement joints will need to be made elsewhere before it can safely be assumed that under local conditions different than those prevailing at Los Angeles such joints will be equally efficient in so reducing the conductivity of a line of water pipe as to make it, even with insulating joints every 12 ft., proof against electrolysis. It is a well-known fact that lead joints frequently break the flow of the electric current through the pipe and that the points where the current leaves the iron pipe are the very ones where the greatest damage from electrolysis generally occurs. Might not the degree of insulation effected by cement joints, under certain conditions of poor rail bonding and consequent heavy stray currents, combined with poor earth return and moisture around the water pipes, multiply the number of points at which electrolysis would occur? Both the water within the main and a moist soil without and around it favor the return of the current to the pipe which, except for the breaks at joints, is many times over a better conductor than either water or earth, and particularly than the ordinary earth at a short distance from the pipe.

LETTERS TO THE EDITOR.

How Should the Yardage of Brick Sewers Be Measured?

Sir: Will you please publish in your next issue the usual method of measuring large brick circular sewers, when let by the cubic yard? I wish to know if it is customary to use the inside or the outside circumference to calculate a section, or whether to take the mean measurement, found by adding the two together and taking one-half the product.

There is a dispute in this matter here, the contractor claiming that it has always been customary to give the external circumference to calculate the area. He claims it as he thinks he is entitled to conventional or builders' measurements.

The specification states that the engineer's measurements shall be final and conclusive, but does not say how his measurements are to be made.

Yours truly, S. G. Miller.

South Sharon, Pa., Dec. 3, 1904.

(We have never heard of any conventional rule of measuring the yardage of a brick sewer by multiplying the exterior circumference by the thickness of the brickwork. It is strictly correct to multiply the mean circumference by the thickness, and in the "Tables and Diagrams for Making Estimates for Sewerage Work," by S. M. Swaab, this method is followed. Since contracts for brick sewer work are usually let by the lineal foot, and not by the cubic yard, this question of measurement is seldom raised.—Ed.)

A Bidding and Cost Record Sheet for Contractors' Use.

Sir: In line with a good deal of discussion, which has recently appeared in your columns concerning bidding prices and actual cost records, the writer begs leave to call attention to a form of bidding and cost sheet. The sheet, excepting some minor changes suggested by Mr. Sanders, is a form gotten up by the writer for A. B. Sanders, Contracting Engineer, who builds water-works, light plants, and sewers; the writer being a civil engineer and superintendent, in charge of construction for Mr. Sanders.

The sheet is self-explanatory, except that perhaps a word concerning the columns, marked "Incidental Cost," may not be out of place. This column is intended to cover costs which would probably not come in, if everything worked out just as might reasonably be expected. But every experienced contractor knows that the unexpected often happens, and only his experience can guide him in filling out this column.

The sheet is 24 ins. wide by 17 ins. deep, and ruled for 41 items. One side of the sheet is headed "Estimate of Cost" on whatever the contract may be, and in whatever city it may be located; while the other side of the sheet is a duplicate of the first except that "Actual Cost" takes the place of "Estimate of Cost." So it is at once evident that the one side serves as a bidding sheet, while the other side is an actual cost record of the same contract. It may be further noted that the sheet is so printed that it may be bound by one edge to form one of the leaves of a book for convenient reference when it is finished and filed for records. The method is simple and does not merit any particular credit, but it may serve as a suggestion to some who are interested in cost records.

Yours truly, Sam'l Young,

Shreveport, La., Nov. 22, 1904.

(We print the headings of the "Actual Cost" side of this record sheet below.—Ed.)

More Concerning Civil Service Examinations.

Sir: I was very much interested in the communication by "Mason" in your issue of Nov. 17. Of course I can readily understand that the editor, not wishing to become embroiled in any civil service discussion, should comment somewhat evasively and look at things "from the large point of view." But, perhaps, to one who has suffered from the very grievances and incongruities of the civil service of which "Mason" speaks, it may be permitted to look at the question from the small point of view, and to point out, not the evils from which the present imperfect system of civil service shields us, but to suggest a few changes, which will approximate more closely the ideas and ideals for which it should stand.

In the first place, I believe that the present arbitrary division of the engineering corps into assistant engineers, transitmen, draftsmen, etc., is not as it should be. An engineer is an engineer whether he be an instrument man in the field, or a draftsman in office. The field man should know the purposes for which work is intended; the limits of error and the difficulties which the draftsman and computer encounter in reducing his notes, so that he may adopt methods to facilitate the office work as far as possible. He should know the office records and have knowledge of the executive work involved in the business administration of an engineering office. The office man should be conversant with field methods, so that he can properly interpret notes and give instructions that do not run counter to good instrument practice. For the above reasons I should classify the engineering corps as Junior and Senior engineers, the Junior engineers including all not in responsible charge of work, and making the requirements of candidates for Junior engineers, such that the one appointed could work either in the field or in the office.

I would likewise like to see methods of examining changed, so as to test an applicant's ability under conditions more akin to those which he encounters in actual practice. With exception of examination in elementary knowledge, I should give the applicant permission to use any and all books of reference, as I take it that it is the engineer's function to know where to find his various data and to know the inter-relationship existing between them, and not to make his brain a storehouse for numberless details and non-essentials.

Besides the above I would strengthen the principle of promotion, of filling the higher ranks from the lower; I should establish salary grades in the two classifications, giving a man the minimum salary upon entrance into the service and giving promotion examinations annually, which should cover the duties and knowledge of details within that particular department, and thus give the engineer the opportunity to rise gradually from the minimum to the maximum salary in his class, when, if he be ambitious he could take an examination for the next higher classification.

If the civil service were modeled more according to ideas above suggested, the unfit, of whom "Mason" speaks, would not find entrance into the service so easy, nor would the untried young collegiate receive the same remuneration as does the man with ten years experience. It is easy to understand why the municipality should be unable to procure a sufficient number of engineers, when it not only pays a low salary (if high cost of living and necessary subtractions be taken into consideration) but likewise shuts out a whole class, such as draftsmen, from any possible hope of promotion.

Respectfully yours, "Skix."

New York, Nov. 22, 1904.

Sir: In your issue of Nov. 24 I read with interest the defence of the Merit System by D. H. R. No doubt any of your readers who are acquainted with Civil Service will agree on the fact that the Civil Service law is a good sound one.

However, the trouble is not with the law, but with its administration and the people charged with its administration. To illustrate, there was recently held in New York city by the Municipal Civil Service Commission an examination for the place of Transitman and Computer. There were papers filed by 296 applicants. Of this number 155 passed, the remainder failed. In looking over the eligible list I found out of 60 names which I had time to examine, 40 of these represented persons who are now holding places as draftsmen, mechanical draftsmen, structural steel draftsmen and topographical draftsmen in the New York city departments. In fact, the larger number of these forty names represented those of persons with no practical experience in transitman's duties. In fact as the city record shows, they have been following the vocation of draftsmen. The most remarkable fact in my mind is that the men who attained the highest percentages have been draftsmen without practical experience in the use of instruments or in field work. Now, as experience counted some 20 or 25 points in 100, and as this examination was held to fill the place of transitman, the duties of which position, as we all know, are largely connected with practical field work, I cannot see, if the examiners had given due weight to field experience in practical work, how these draftsmen could have qualified at *all* for this position. I am forced to the conclusion that this remarkable state of affairs could only have been brought about in one of two ways, either by false swearing on the part of the candidates as to the nature of their experience, or else to the fact that the examiners who marked the experience sheets were grossly incompetent or else were totally ignorant of what constituted field experience for transitmen.

In my mind, it is just such occurrences as these which

Actual Cost of* ..... Contract at ..... 190..

Item.	Manufacturer	Quantity	Size	Unit Cost f. o. b. Work.	Total Cost f. o. b. Work	Unit Cost Construction	Total Cost Construction	Incidental Cost	Total Cost in Place	Amount Added for Profit	Contract Price	Remarks.

*Opposite side of sheet reads: Estimate of Cost On....

discourage competent men from participating in examinations and which tend to bring the Civil Service law into disrepute. The facts in the above letter I ascertained by a comparison of the roster of city employees, as given in the City Record, with the existing eligible list which resulted from the above-mentioned examination.

Very truly yours, J. F. S.

New York, Nov. 27, 1904.

(Is not our correspondent passing judgment with incomplete knowledge of the facts? Is there anything strange in the fact that a competent draftsman is able to pass a satisfactory examination for a transitman's place? We think it altogether probable that a good percentage of these draftsmen were graduates of engineering schools and more or less familiar with the use of field instruments. Such men, we believe, will often make instrument-men quite as competent and efficient as men who have already had experience in the field.

It is a common enough criticism of the merit system to say that too little weight is given to past experience in the marking of candidates; but it is an open question where the choice should be made between experience and ability. Many a chief engineer on railroad work has made most capable instrument-men by promoting rodmen and draftsmen. It often happens that a bright, active young fellow, with the proper educational groundwork, will when thus promoted excel in a short time men of much longer experience. Let us remember that what we want is *merit*. Let the best and ablest man win. To give too little weight to past experience is undeniably wrong; but it is also wrong to set experience so high that we shall lose from the "eligible" list the young men with surpassing ability, whose experience is still to be gained.—Ed.)

The Failure of the Smith Avenue Bridge in St. Paul, Minn.

Sir: I have read with great interest the reply from the Commissioner of Public Works of St. Paul to my letter printed in Engineering News of Oct. 27, 1904.

Notwithstanding the information given and the conclusions drawn by the city engineer, I am still of the opinion that the absence of the nuts on the anchor bolts is of the greatest importance in determining the cause of the wreck, and that without making the assertion that the city engineer's "observations are erroneous." I think it is fair to request of an opponent that he shall make himself familiar with the facts and conclusions he will dispute, and *prove* that the observations and conclusions are wrong, rather than *assert* it.

I was, myself, within the influence lines of the storm; scores of big trees blew down and blocked the streets around the building from whose second floor I watched the destruction when the lightning afforded an opportunity. A well-built two-story frame house was moved about 8 ft. out from its foundation within less than 700 ft. from my place. In the evening after the storm had passed, and the following day, I visited most of the places where damage had been done, and I have inspected the wrecked bridge several times. On most of the unroofed residence buildings the connections between the rafters and the wall plates had slipped. The soil was very soaked from the previous heavy rainfall, thereby decreasing the resistance against overturning of trees; I noted one case where the soil was simply pressed down on the leeward and forced up on the windward side, leaving the root in the hole.

The Tivoli and Empire theaters are the buildings referred to by the city engineer as located on either side of the Wabasha St. bridge. The Tivoli theater was an old frame house connected to the rear end of a brick building which formed the refreshment room. The frame house is entirely destroyed, the brick part being only damaged. The Empire theater, on the windward side of Wabasha St. bridge, was unroofed and the glasses broken, while the brick walls were left intact. A suspended platform on this building close up to the sidewalk of the bridge lost its flooring entirely, but the sidewalk deck of the bridge was not damaged, nor any other part of this bridge. The city engineer considers these buildings as lying within the influence lines of the same bolt of the wind which destroyed the Smith Ave. bridge, an opinion I fully agree with. It seems to me, however, that the destruction done at this point cannot warrant the inference that the storm could lift or overturn a substantial structure when in proper shape. Of course it is a distance of about one mile from the wrecked bridge down to this point, and the storm might have changed somewhat in force and character on this way; but, as the city engineer says, "the line of the cyclonic influence was sharply defined" and "its course was plainly marked across the island" and "struck the top of the bluff at the north end of the Wabasha St. bridge," the point I have just referred to in the above.

Turning to the condition at the Smith Ave. bridge, I shall again mention the important facts, viz.: that the two nuts on the northwest leg of the overturned tower were not in place at the time of the accident, and that the threads were painted. Further facts are that the bolts on the southeast leg of the same tower, diagonally opposite the leg with the missing nuts, are bent southeasterly in a direction nearly parallel to the diagonal. Why should this be the case unless the leg without nuts on the anchor bolts was the first one to give way, thereby giving a diagonal movement to the entire tower?

The diagonal movement of the tower would try to pull the 250-ft. span from its supports on the expansion bearings at its northern end, and as the windward side of the span would be most affected by the tipping of the tower, the bearing on this side has evidently slipped first.

The condition of the roller bed can hardly be used as a proof for either of the two theories, at least I am entirely unable to see why the bed on the windward side should be more damaged than on the leeward side if the bridge was lifted up; while the overturning of the tower *could* affect the roller nests in this way.

In forming my theory as to the cause of the wreck I also took the position of the wrecked 250-ft. span into consideration as an evidence. The tipping of the tower would have a tendency to throw the south end of this span farther out from the axis of the bridge than the north end, and the more rigid connection of the fixed (south) end of the span to this tower would, perhaps, increase this tendency, since this connection might have slipped later than the expansion end. The action of a storm able to destroy the bridge would also prevent the 250-ft. span from falling vertically, and I think the distance from the center line of the bridge to the north end of the wrecked 250-ft. span may readily be accounted for by this action; also the position of the wrecked tower, the pedestals being some 5 to 8 ft. above the ground.

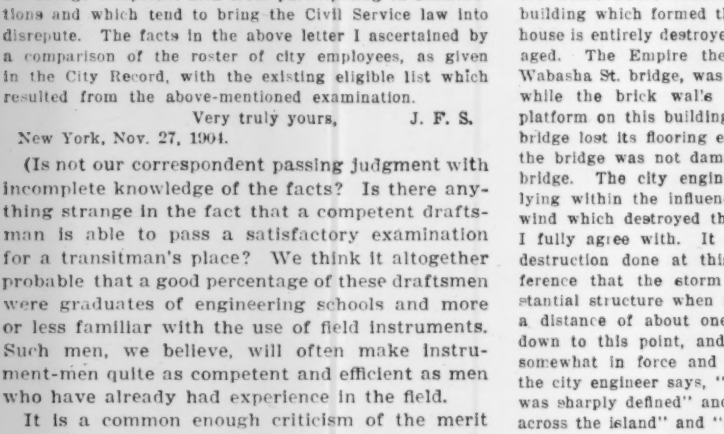
I never doubt that a tornado sometimes can have an uplifting action, and also a cyclonic character. The position of the wrecked 250-ft. span, however, does not indicate any strong cyclonic motion, and the slight twisting of the tower may very well be due to the absence of the nuts. That the tornado approached from the west is, on the contrary, a well proved fact.

The conditions will be more fully explained by the accompanying sketch.

One of the nuts at the southeast leg of the overturned tower was also missing, but as this was the leeward side of the bridge, the influence of a missing nut was practically nothing as far as the overturning is concerned, while it would have been of importance in case the bridge was lifted up.

As to the uplifting, the iron frame does not afford a very great surface for such an action, and the deck was fastened with steel wire nails clinched under the flanges of the stringers and was not built to carry a load of over 350 tons* and break anchor bolts of additional 380 tons' strength in the same way as a parachute carries a man

The Tenth Ave. bridge in Minneapolis was wrecked during the same storm, the deck being lifted off from the iron frame, which is not damaged, though the iron structure repeatedly has been condemned as unsafe. Would not a similar upward pressure on the Smith Ave. bridge also tear off the deck and leave the bridge standing?



SKETCH OF WRECKED PORTION OF SMITH AVENUE BRIDGE, ST. PAUL, MINN.

Tornado of Aug 20, 1904, approached from West. Double arrows at tower legs in plan indicate direction of expansion movement. For photographs of the ruins and a fuller description of the bridge see Eng. News of Sept. 1, 1904.

*The dead load of the structure is calculated from formulas given in Johnson's "Theory of Modern Structure," and the ultimate strength of the wrought-iron anchor bolts is taken as 45,000 lbs. per sq. in.

The stability against overturning of the four-leg tower with its proper length of spans was about fourteen million foot-pounds; the two 1¾-in. anchor bolts on the west side (those actually in place) increased this by about twelve million foot-pounds. To overcome the overturning stability is required a force of about 100 tons, applied about 20 ft. below the deck. Consequently the bridge could be overturned by about two-sevenths of the force required to lift the bridge. If the weight of the deck and the strength of the anchor bolts with nuts actually on is taken into consideration this fraction would be reduced to about one-ninth.

The bridge was designed for 450 lbs. wind pressure per lineal foot of bridge, giving a total overturning moment on the four-leg tower of about sixteen million foot-pounds, or about the same as the resistance against overturning of this part of the bridge without anchor bolts.

The engineer designing the bridge was very well aware that the resistance must exceed the overturning force, or he would not have provided such large anchor bolts. He also knew the necessity of the nuts, or he would not have furnished the anchor bolts with cotter holes, to prevent the nuts from getting loose. There is, however, no indication that these cotters were replaced at the time of the repair in 1899.

The anchor bolts when in perfect order would have increased the inherent stability of the bridge by about 650 tons against uplifting, and by about thirty-six million foot-pounds against overturning, which is about two versus two and one-half times the stability of the unanchored bridge, respectively.

The missing nuts decreased the resistance against uplifting by about 270 tons, and against overturning by about twenty-four million foot-pounds, or in other words, at the time of the accident the bridge was only about half as stable as designed.

Without saying whether the action of the storm was strictly horizontal or slanting, there can hardly be any doubt that the bridge failed by overturning, against which the bridge had lost about 50% of its resistance on account of the missing nuts.

Yours very truly, R. A. Tanner, C. E.

385 Grove St., St. Paul, Minn., Nov. 25, 1904.

Notes and Queries.

Several correspondents call our attention to an error in placing the decimal point in the editorial comment on "A Weak Horse-Power" (p. 505 of our last issue). Correctly stated it should read that 16 HP. is theoretically capable of lifting at the rate of 1 ft. per hour a weight of 31,680,000 lbs.

FAILURE OF A RESERVOIR BOTTOM AT RED WING, MINN.

By F. H. Bass.*

A peculiar reservoir failure occurred at Red Wing, Minn., on Saturday, Nov. 19, about 7 p. m. The reservoir is situated upon the side of a steep hill, about 150 ft. above the foot of the slope. It was built in the fall of 1884 by the Northwestern Gas & Water Co. of Minneapolis, and as far as the writer could ascertain no skilled representative of the city inspected the work.†

The reservoir (Fig. 1) is circular in plan and has an inside diameter of 80 ft. It is about 30 ft. deep at the center and 26 ft. deep at the side, and had a capacity of 1,000,000 gallons. The foundation is entirely in excavation and consists of a St. Lawrence shale grading from fine sandstone at the reservoir bottom to clay shale some 50 ft. below.

On the upper side of the hill the original rock extends to the top of the reservoir and on the lower side a few feet only above the bottom.

The wall is said to vary in thickness from 2 to 14 ft.

The bottom of the reservoir was covered by a layer of concrete varying in thickness from 4 ins. to 1 ft., and it was through this concrete that the break occurred.

According to a statement by Mr. W. I. Wilson, Superintendent of Water-Works, a light crack had for some time existed in the reservoir bottom, but it appeared to be on the surface only and no attention other than a little patching was given to it. After the accident it was found that the

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(†According to "The Manual of American Water-Works" for 1888, Mr. H. H. Harrison, of Stillwater, Minn., was designing and consulting engineer for the city waterworks built in 1884; Mr. G. E. Beach, of Minneapolis, was constructing engineer; and the Northwestern Water & Gas Supply Co., of Minneapolis, was the contractor. Possibly, Mr. Beach was engineer for the contractor and not for the city. The "Manual" appears to be in error as to the dimensions and shape of the reservoir, which it gives as rectangular, 18 × 400 ft., × 20 ft. deep, 235 ft. above pumps and 210 ft. above city.—Ed.)

concrete flooring was broken at a point in this crack and there was a hole, shown at A, Fig. 1, some 3 or 4 ft. in diameter and 2 or 3 ft. deep, at one edge of which was a large crack in the sandstone extending entirely across the reservoir. The crack was about 3 ins. wide at the top, and varied in depth from 2 to 18 ft., and in width at the bottom from 3 ins. to 2 ft. or more.

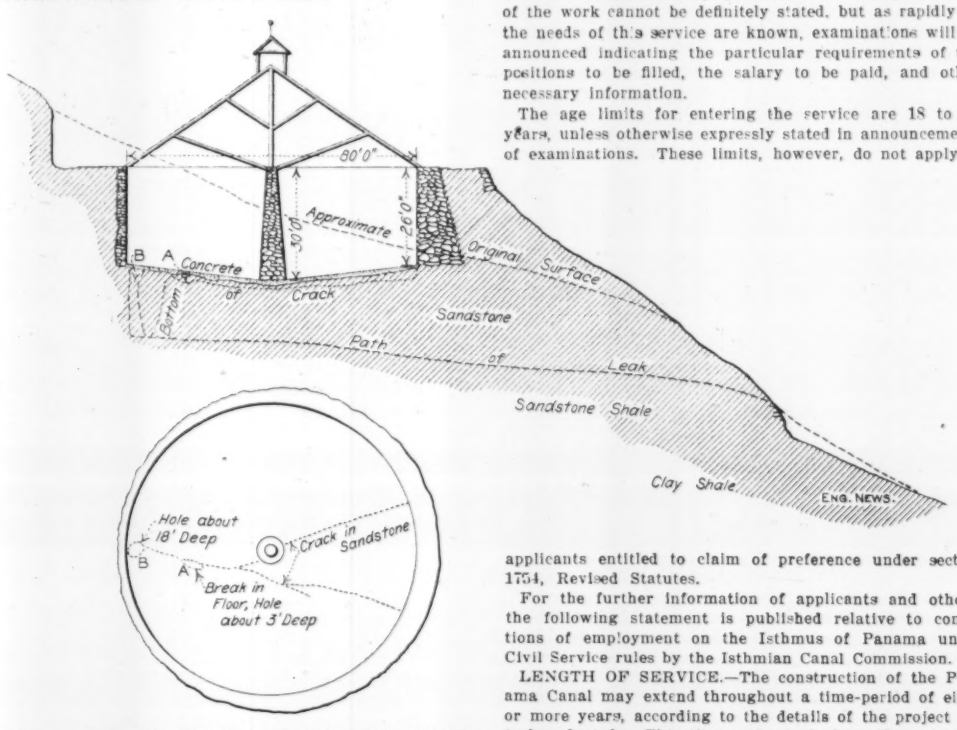


FIG. 1. SKETCH PLAN AND SECTION ILLUSTRATING FAILURE OF RESERVOIR BOTTOM AT RED WING, MINN.

At the end of this crack, near the wall, was another hole (B) about 3 ft. in diameter and 18 ft. deep. It was through this latter hole that the greater part of the water probably escaped. It then flowed under the reservoir bottom and to the surface at the side of the hill, a distance of 150 ft., where it caused the damage which is shown in the accompanying view, Fig. 2.

The crack or seam probably existed at the time of the construction of the reservoir, and if it had been properly grouted at that time this failure would not have occurred. Again, if the concrete floor had been of sufficient thickness and imperviousness any small leak would not have had an opportunity to undermine the floor and perhaps enlarge a small crevice to one which eventually caused the accident.

The leak was discovered by a near-by resident who heard a hissing noise and upon investigation found the large volume of water issuing from the hillside. He shouted a warning which was heard by a boy who lived in a house just below the break, the wreck of which is shown in Fig. 2. The boy rushed into the house and warned his mother of the impending danger, and the two barely escaped from the house before it was struck and demolished by the escaping water.

CONDITIONS OF EMPLOYMENT UNDER THE ISTHMIAN CANAL COMMISSION.

The following circular was issued by the U. S. Civil Service Commission, at Washington, D. C., Dec. 3:

On November 15, 1904, the President, by Executive order, placed the employees of the Isthmian Canal Commission under the provisions of the Civil Service act and rules, excepting persons employed merely as laborers, persons whose appointments are confirmed by the Senate, and engineers detailed from the United States Army. This order, however, excepts from the requirement of competitive examination a number of positions specifically enumerated under Schedule A. (See note.)

With these exceptions all positions of whatever character or designation under the Canal Commission, whether in the United States or upon the Isthmus of Panama, are subject to the requirement of competitive examination. Vacancies in clerical and other positions in the office of the Canal Commission in Washington will be filled as far as practicable from suitable existing registers of eligibles, but for positions on the Isthmus of Panama examinations will be held at various cities throughout the United States and also upon the Isthmus, as the needs of the service may require. Qualified eligibles on existing registers may, however, be certified to such positions in the absence of registers prepared as a result of special examinations for the Canal Commission. At the present time the number of employees needed in many branches of the work cannot be definitely stated, but as rapidly as the needs of this service are known, examinations will be announced indicating the particular requirements of the positions to be filled, the salary to be paid, and other necessary information.

The age limits for entering the service are 18 to 40 years, unless otherwise expressly stated in announcements of examinations. These limits, however, do not apply to applicants entitled to claim of preference under section 1754, Revised Statutes.

For the further information of applicants and others, the following statement is published relative to conditions of employment on the Isthmus of Panama under Civil Service rules by the Isthmian Canal Commission.

LENGTH OF SERVICE.—The construction of the Panama Canal may extend throughout a time-period of eight or more years, according to the details of the project yet to be adopted. (This time estimate is from the report of the last Isthmian Canal Commission.)

OPPORTUNITIES.—The Civil Service of the Isthmian Canal Commission offers excellent opportunities to qualified persons, both in the matter of salaries and promotion. Under the operation of the Civil Service law it is contemplated that promotions will be made upon the basis of merit from the lower to the higher positions.

MEDICAL ATTENDANCE.—Medical attendance, medicines, and care at hospitals when sick, are furnished to the employees of the Isthmian Canal Commission without cost. Well-equipped hospitals will be maintained at Ancon, adjacent to Panama, and at Colon.

In meritorious cases sick leave on pay may be allowed, in addition to the regular leave of absence, not to exceed 30 days for employees who are from the United States, or 15 days for employees who are residents of the Isthmus.

ACCOMMODATIONS FOR EMPLOYEES.—The Isthmian Canal Commission furnishes quarters to its American employees, or at its option in lieu thereof commutation, which has tentatively been fixed at 8% of the salary. The Commission proposes to maintain a civil commissary department on the Isthmus, which is soon to be established and the advantages of which are to be made available to the salaried employees of the Commission.

TRANSPORTATION TO THE ISTHMUS.—The Isthmian Canal Commission furnishes its employees free transportation to the Isthmus from either New York, New Orleans or San Francisco, and, also, free return transportation upon completion of satisfactory service.

LEAVE OF ABSENCE.—The employees of the Isthmian Canal Commission are allowed six weeks' leave of absence annually on full pay. This leave of absence is not granted until after eight months of satisfactory service. In visiting the United States on leave, employees and members of their immediate families are granted special rates to the above-named ports. (The prevailing special rates are $25 between New York or New Orleans and Colon, and $70 between San Francisco and Panama.) The special rates also apply when members of the family of an employee accompany him to the Isthmus.

SALARIES OR WAGES.—All salaries or wages paid by the Isthmian Canal Commission to employees from the United States are in gold or its equivalent in United States currency.

All inquiries concerning examinations for competitive positions under the Isthmian Canal Commission should be addressed to the United States Civil Service Commission, Washington, D. C.

Further communication relative to service, situation, climate, and conditions on the Isthmus should be addressed to the Isthmian Canal Commission, Washington, D. C., by whom the foregoing details have been furnished.

In all cases where no examination is pending for the position which the applicants seeks, his name will be placed upon a mailing list and he will be promptly informed as soon as an examination of the kind desired is announced.

NOTE.—SCHEDULE A.—By Executive order appointments to excepted positions under the Isthmian Canal Commission in the schedule below may be made without examination or upon noncompetitive examination, but the proper appointing officer may fill an excepted position as competitive positions are filled, in which case the person appointed will receive all the rights of a competitive employee.

Secretary, Assistant Secretary, Executive Secretary to the Governor of the Canal Zone, Chief Clerk, Treasurer, One Deputy Treasurer, One Chief of Materials and Supplies, Auditor, Two Deputy Auditors, One Disbursing Officer for the Canal Zone, One Collector of Revenue, Chief Engineer of the Commission, Division Engineers as hereinafter to be provided for, Resident Engineers as hereinafter to be provided for, Hospital Attendants other than

FIG. 2. SHOWING COURSE OF ESCAPING WATER FROM UNDERGROUND BREAK IN RED WING RESERVOIR.

(The location of the reservoir is shown by the top of the roof, on the bluff, and the place where the water broke through the hillside to the surface is shown below and to the left of the location of the reservoir, as indicated approximately by the white cross.)

nurses and clerical force, Chief Sanitary Officer, Assistant Sanitary Officers as hereinafter to be provided for, Director of Hospitals, Superintendents of Canal Hospitals, one for each hospital, Chief Quarantine Officer, Two Assistant Quarantine Officers, Sanitary Officer at Colon, Sanitary Officer at Panama.

For information concerning these positions inquiries should be addressed to the Isthmian Canal Commission, Washington, D. C.

In accordance with the above circular, examinations are announced for the following positions in the Panama Canal service:

Miners at $100 to $125 per month. Steam-shovel man, $190 per month with bonus for extra quantity of work done. Steam-crane man, $165 per month with bonus for extra quantity of work done. Firemen and helpers on steam shovels, $75 per month. Foreman carpenter, $100 per month. General foreman of laborers, $100 to $125 per month. Foreman of laborers, $75 to $83.33 per month. Assistant foreman of laborers $50 to $60 per month. Foreman of diamond-drill boring party, $150 per month. Foreman of wash-boring party, $125 per month; boring party helper, $75 per month.

For all the above positions no educational tests are required and applicants do not have to appear at any particular place for examination. They will be rated on age, physical condition and experience as shown by their record in past work. Only citizens of the United States are eligible. Persons desiring to apply for any of the above positions should at onceaddress to the U. S. Civil Service Commission, Washington, D. C., a request for a copy of the blank describing the qualifications necessary for the position which they wish to apply for and a copy of application Form 1052.

Besides the above, an examination is to be held early in January for male stenographers and typewriters in the Panama service at $1,200 to $1,500, with opportunities for promotion to $1,800. Applicants should write for circular No. 13 and Application Form No. 304.

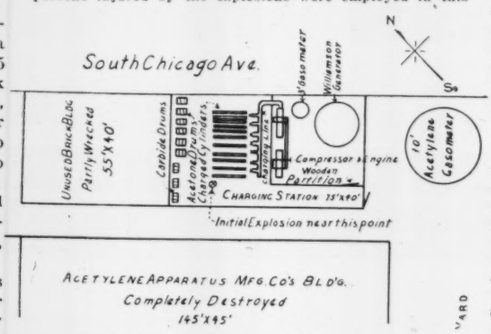
A FIRE AND EXPLOSION IN AN ACETYLENE GAS PLANT.

On Nov. 18. 1904, a large acetylene gas charging plant in Chicago, Ill., was wrecked by a series of explosions and a fire. Four men were killed in the accident, many others were injured, and much property was destroyed. Pending an investigation of the accident by the authorities, details of the accident have been difficult to obtain, and we have deferred making note of the case until a satisfactory amount of information was available. A brief account of the events is given by Messrs. W. C. Robinson and M. Moskowitz in a bulletin of the National Fire Protection Association, which we reprint below. The plant was operated by the Pyle National Headlight Co., for charging tanks of acetylene by acetone absorption, for use in railway car lighting on the Commercial Acetylene Car-Lighting System. It was located on South Chicago Ave., near 73d St. The accident occurred about 10 a. m.

This (one-story) station contained at the time: 15 to 20 steel cylinders (sizes, 30 ins. long by 6 ins. diam. to 96 ins. long by 16 ins. diam.) all containing asbestos, acetone and acetylene gas, said to be initially compressed to maximum pressure of 400 lbs. per sq. in., afterwards reducing to normal of 240 lbs. by absorption in acetone, these cylinders being in process of charging preparatory to shipment for attachment to railway car lighting systems; at least five 100-gal. steel drums containing acetone; at least five steel drums, each holding 1,000 lbs. calcium carbide; one two-stage compressor driven by a small steam engine; one Williamson central station acetylene gas generator rated for 500-lb. carbide charge and connected to a 30-ft. gasometer located outside building and then to a gas meter and a 3-ft. gasometer located inside building.

The initial explosion occurred in the northwest portion of the structure. The cause is unknown, all of the employees on the scene being instantly killed. Fire communicated to the combustible contents of the building, and the acetone, liberated by rupture of the drums, added enormously to the volume of heat. This heat acted on the sealed gas storage cylinders and they exploded one after the other, many parts of them being hurled distances varying from 100 to 200 ft. The brick walls of the building were thrown down, its metal roof was carried through a distance of 100 ft., the front of a two-story frame building 300 ft. distant was demolished, and windows in the vicinity were broken, all apparently due to the force of the first explosion. The Williamson generator and the gasometers were uninjured; the compressor, while badly wrecked externally, showed no evidence of having been subject to the force of an internal explosion.

Some of the carbide drums were broken, and the material, when acted upon by water from hose streams, liberated acetylene gas which was ignited and contributed a small amount to the loss. All of the other contents of the building were totally wrecked by the force of the explosions and fire, and a large 3-story brick factory building on the west, occupied by the Acetylene Apparatus Mfg. Co., manufacturers of acetylene gas generators, was destroyed, together with its contents. Most of the persons injured by the explosions were employed in this



Map of Plant of Pyle National Headlight Co., Chicago, Ill., Wrecked by Explosion on Nov. 18, 1904.

factory. A shed and a coke pile about 150 ft. distant were also burned.

Many theories are advanced covering the cause of the initial explosion, but, because of the killing of all eye witnesses and the total destruction of the apparatus directly contributing, no facts have yet been shown in conclusive proof of any of them.

The engineers of the National Board of Fire Underwriters had previously objected to the use of pressures higher than 150 lbs. in acetylene storage tanks at the plant in question.

EXPORTS OF MANUFACTURES in the calendar year 1904 will not only exceed the highest figures of any earlier year, but may probably pass the $500,000,000 line, as against 434 millions in the high-record year, the fiscal year 1900, 151 millions in 1890, 103 millions in 1880, 68 millions in 1870, and 40 millions in 1860. Not only will manufactures as a whole make their highest record during the present year, but this is also true of iron and steel manufactures, which form the largest group of manufactures exported and which seem likely to show for the calendar year a total exportation of 130 million dollars, as against 122 millions in the high-record fiscal year 1900, 26 millions in 1890, 15 millions in 1880, 13 millions in 1870, and 6 millions in 1860.

WATER FILTRATION AT PITTSBURG, PA., has again been brought to the front, this time by the introduction of ten ordinances in the select council. The ordinances provide for filter beds costing $3,600,000; also for pumping plant, sand washers, clear water reservoir, river intake and pipe lines, bringing the total cost of the proposed improvements up to $6,000,000. The ordinances were referred to the committee on filtration. Most of the money for this work would come from a recently authorized bond issue of $5,000,000 which is now in the courts, owing to the refusal of the city controller to advertise for bids for the bonds. W. B. Hayes is Mayor of Pittsburg; E. M. Bigelow is Director of Public Works, and Morris Knowles, M. Am. Soc. C. E., is Filtration Engineer.

THE NEW YORK ADDITIONAL WATER SUPPLY question has again been referred to the members of the Burr-Hering-Freeman Commission. As we noted a few weeks ago, Mr. Geo. W. Birdsall, Acting Chief Engineer of the Department of Water Supply, Gas and Electricity, recently reported a $90,000,000 plan, differing in some material respects from the plan submitted a year ago by the commission. On coming up in the Board of Estimate and Apportionment, Mayor McClellan suggested the reference mentioned above and it was agreed to by the board.

A $916,703 CONTRACT FOR STEEL AND CAST-IRON book-stacks for the New York Public Library was awarded on Nov. 18 to The Snead & Company Iron Works, of Jersey City, N. J. Doubtless this is the largest contract of the kind ever made. It includes over 80 miles of shelving, with room for 4,000,000 volumes. This is at the average rate of about $2.17 per ft. of shelving, or 23 cts. per volume shelved. But unit prices are misleading, since the contract includes structural work for the support of the seven tiers of stacks in the main stack room, which stacks are 53 ft. high and 78 × 297 ft. in plan. In addition to the main stacks there is shelving in 58 rooms throughout the building. The Snead shelf, which has been in use in the Library of Congress for some years, is made up of cold rolled steel trough bars, with ⅜-in. open spaces between, supported on perforated cast-iron verticals. The openings in the shelves and uprights afford light and ventilation for the books, besides reducing the weight of metal. Of about 142,000 shelves 132,000 are movable, but adjustments are made without screws, ratchets, cleats or any loose pieces save the shelves themselves. Another feature of the stacks is that they afford a minimum of space for the lodgment of dust and of living book enemies. The weight of the stacks and books in the main stack room is transmitted by means of star-shaped steel columns to a heavy concrete floor in the cellar. There were five other bidders for the contract, ranging from $969,025 to $734,310, all but the highest of these being lower than the accepted bid. The architects for the New York Public Library are Carrere & Hastings, of New York City.

BIDS FOR LARGE PUMPING ENGINES have recently been opened at Chicago and Milwaukee. The Department of Public Works at Chicago has received bids for two engines of 40,000,000 gallons daily capacity, one for the Central Park Ave. pumping station and the other for the Springfield Ave. pumping station. These are to be vertical triple-expansion engines, having the capacity above mentioned against a normal head of 120 ft. (not including the friction of water through the suction piping and pumps); they are also to be capable of pumping the same amount, when required, against a maximum head of 140 ft. (exclusive of friction, as before) when supplied with steam of 140 lbs. pressure at the throttle. They are to be designed to work under a maximum steam pressure of 150 lbs. at the throttle, with superheat not exceeding 150° F. There will be the largest engines of the type ever built, and the bids were as follows: Allis-Chalmers Co., $200,000 for engines of the Riedler type, or $223,600 for the Allis-Reynolds type; Wm. Tod Co., $227,000 for the Reynolds vertical triple-expansion type; Henry R. Worthington, $178,500; Holly Mfg. Co., $201,900. The city will also install at the 68th St. pumping station a horizontal compound condensing pumping engine with a capacity of 20,000,000 gallons per day against a normal head of 125 ft.——The city of Milwaukee, Wis., will install a pumping engine of 20,000,000 gallons capacity at the North Point pumping station of the city water-works. This is to be a vertical, triple-expansion, crank and flywheel, three-plunger condensing engine, and the specifications called for a minimum duty of 160,000,000 gallons. The bids opened on Nov. 20 were as follows:

	Price.	Duty, gallons.
Filer & Stowell Co.	$67,900	160,000 000
Wm. Tod Co. (A)	68,200	160,000,000
Wm. Tod Co. (B)	72,000	167,000,000
Wm Tod Co. (C)	76,000	167,000,000
Allis-Chalmers Co.	65,000	168,000,000
Brown Corliss Engine Co.	64,500	162,500,000

This is the fourth time that bids have been received for this engine, there having been trouble over a clause in the contract requiring the contractor to work only an eight-hour day.

Bids were first received on June 15, but were rejected for the reason that since the call for bids was issued the council had passed a resolution requiring that the specifications should require that only eight-hour labor should be employed on the work. At the next bidding, on July 2, the lowest bidder in the first case refused to make a bid, claiming that it was entitled to the contract; two other firms made bids but refused to agree to the eight-hour clause, and the third bid was very high. The three bids were rejected. On July 15 the contract was awarded to the firm which had made the lowest bid in the first case, the firm agreeing to the eight-hour clause. This contract, however, was attacked in the courts on the ground that such a clause was unconstitutional. This view was upheld by the courts and the contract was canceled. The eight-hour clause was therefore omitted from the specifications under which the latest bidding was made.

THE ARTESIAN WELL CO. OF YUCATAN, of Merida, Yucatan, in drilling for oil and natural gas in the vicinity of Merida struck, at a depth of 400 ft., a deposit of iron pyrites showing 62% of metallic iron, with $16 in gold to the ton. The drill entered the deposit 39 ft. when work was suspended. As shown by other test wells driven in the neighborhood, the deposit extends at least for a length of 3.7 miles. The interesting feature of the deposit is that it is the first discovery of any metallic ore deposit in Yucatan

A RAILWAY MUSEUM may be formed as a result of the St. Louis Exhibition, the large historical locomotive collection of the Baltimore & Ohio Ry., and other exhibits, forming the nucleus. The historical collection referred to was exhibited at the Columbian Exhibition at Chicago in 1893 and afterwards presented to the Field Columbian Museum at Chicago, which was established as an outcome of the exhibition. This institution, however, has practically decided to confine its scope to pure science, and the applied science section may be abolished. The disposal of the Baltimore & Ohio Ry. collection is at present uncertain, but the establishment of a railway museum at Philadelphia has been proposed, and a large building has been offered for the purpose. Mr. J. G. Pangborn is Director of the Baltimore & Ohio Ry. Co.'s exhibit.